Agriculture
Canada

RESEARCH BRANCH REPORT

1984

RAPPORT DE LA DIRECTION GÉNÉRALE DE LA RECHERCHE

Canada

Research Branch Report

1984

Rapport de la Direction générale de la recherche

RESEARCH BRANCH
DIRECTION GÉNÉRALE DE LA RECHERCHE

AGRICULTURE CANADA

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FOREWORD

The *Research Branch Report* is an annual publication of the Research Branch of Agriculture Canada. It includes brief summaries of research results obtained during 1984, as well as listings of management, research staff, and publications.

Research programs in the branch are developed in response to the needs of the agri-food industry, as determined through the mechanism of the Canadian Agricultural Services Coordinating Committee and consultations at all levels of the industry. These programs must be consistent with the department's agri-food strategy for Canada, as outlined in the 1981 document "Challenge for Growth". Program reviews, usually involving a number of external authorities, are conducted regularly; each commodity or discipline is usually examined at 5-yr intervals. During 1984, national reviews were completed for beef research, for potato pathology, and for the program on international assistance to developing countries.

During 1984, an operational planning framework (OPF) was approved and implemented by the branch. All research is now organized under four sub-elements, namely resources and support, animal productivity, crop productivity, and food research (see "Program Structure", page xiii).

The five regions of the Research Branch, namely Atlantic, Quebec, Ontario, Prairie, and Pacific, include 29 major establishments, as well as a number of smaller units. Each one carries out research contributing to national and regional objectives while developing technology pertinent to the specific area where it is located. In addition to establishments in the regions, the Institutes Directorate includes five research institutes in Ottawa that combine research on national programs with special services to regional establishments and the public. A Program Coordination Directorate, located at Branch Headquarters in Ottawa, coordinates research programs at the national level and develops policies consistent with furthering the objectives of the branch.

In 1984, the Research Branch operated with a budget of $237 million and 3594 person-years, including 918 for professional persons. Under the capital strategy plan the branch had a budget of $50 million for the construction or improvement of research facilities. These resources are supplemented by contracts and grants to stimulate research by agencies outside the department. Priority is given to projects related to energy, agricultural mechanization, food processing, reduction in the use of chemical pesticides, and biotechnology.

The Research Branch cooperates with other branches of Agriculture Canada, with other federal departments, and with various agencies in activities related to the agri-food sector. It also provides research assistance in developing countries and trains their scientists in Canada.

Research results are reported in both scientific and extension-type papers, listed at the end of each station's report. This information is passed on through various provincial committees and technology-transfer mechanisms to the producers and food processors. From the plant-breeding programs of the branch, 20 new cultivars were licensed or released in 1984. For the first time, three potato seedlings were offered competitively to commercial companies on an "exclusive rights" basis, primarily for export seed sale. Also the first triple-M wheat (medium protein, medium gluten strength, medium kernel hardness) HY-320 was licensed for Canadian production. Following extensive research and extended negotiation, Canadian rapeseed (canola) was granted GRAS status (generally recognized as safe) in the United States, thus opening major potential markets for this important crop.

Subsequent sections of this report present listings of management and research staff, research results, and publication lists for each establishment, by region, within the Research Branch.

E.J. LeRoux
Assistant Deputy Minister, Research

AVANT-PROPOS

Le *Rapport de la Direction générale de la recherche* est une publication annuelle de la Direction générale de la recherche d'Agriculture Canada. Il comprend de brefs sommaires des résultats de recherches obtenus en 1984 ainsi que des listes des publications et du personnel de la recherche et de la gestion.

Les programmes de recherches de la Direction générale sont élaborés en réponse aux besoins du secteur agro-alimentaire mis en lumière par l'intermédiaire du Comité de coordination des services agricoles canadiens et de consultations effectuées à tous les niveaux du secteur. Ces programmes doivent être compatibles avec la stratégie agro-alimentaire du Ministère pour le Canada, décrite dans le document de 1981 intitulé

Le défi des années 80. Les programmes font l'objet d'examens réguliers, ce qui nécessite habituellement la participation d'un certain nombre d'administrations externes; on examine généralement chaque produit primaire ou discipline tous les cinq ans. Au cours de 1984, des révisions ont été effectuées à l'échelle nationale pour la recherche sur le boeuf, la pathologie des pommes de terre et le programme d'aide internationale aux pays en développement.

Sur le plan de l'organisation, la région Ouest de la Direction générale a été divisée, au cours de 1984, en deux régions, celles des Prairies et du Pacifique, et son administration est déménagée de Saskatoon à Régina et à Vancouver. Ces changements ont permis de porter une attention plus particulière aux problèmes agricoles propres à cette région diversifiée. À la Ferme expérimentale centrale, une étude approfondie a été menée sur la future structure organisationnelle de l'établissement et un rapport a été envoyé à la haute direction du Ministère.

En 1984, un Cadre de planification opérationnelle (CPO) a été approuvé et mis en vigueur par la Direction générale. Toute la recherche est maintenant organisée en fonction de quatre sous-éléments: ressources et soutien, productivité des animaux, productivité des cultures, et recherche sur les aliments (voir "Structure de programme", page xiv).

Les cinq régions de la Direction générale de la recherche, soit l'Atlantique, le Québec, l'Ontario, les Prairies et le Pacifique, comprennent 29 établissements principaux ainsi que de nombreuses unités de moindre importance. Dans chacune d'elles, on exécute des recherches en fonction des objectifs régionaux et nationaux, tout en élaborant une technologie appropriée à la région particulière où se trouve l'unité. De plus, de recherches situés à Ottawa qui allient la recherche sur les programmes nationaux à la prestation de services particuliers aux établissements régionaux et au public. Un programme de la Direction de la coordination, située à l'administration centrale à Ottawa, coordonne des programmes de recherches à l'échelle nationale et élabore des lignes d'action en accord avec les objectifs de la Direction générale.

En 1984, la Direction générale de la recherche a fonctionné avec un budget de 237 millions de dollars et 3 594 années-personnes, dont 918 s'appliquaient à des professionnels. Dans le cadre du plan de la stratégie d'immobilisation, la Direction générale avait un budget de 50 millions de dollars pour la construction et l'amélioration de l'équipement de recherche. À ces ressources s'ajoutent des contrats et des contributions visant à encourager la recherche par des organisations de l'extérieur. La priorité va aux projets portant sur l'énergie, la mécanisation agricole, la transformation des aliments, la réduction de l'utilisation de pesticides chimiques et la biotechnologie.

La Direction générale de la recherche collabore avec d'autres directions générales d'Agriculture Canada et d'autres ministères fédéraux ainsi qu'avec divers organismes dont les activités sont reliées au secteur agro-alimentaire. De plus, elle fournit aux pays en développement une aide à la recherche et elle forme leurs chercheurs au Canada.

Les résultats des recherches paraissent dans les ouvrages scientifiques et les articles de vulgarisation énumérés à la fin de chaque rapport de station. Cette information se rend jusqu'aux producteurs et aux établissements de transformation des aliments en passant par divers comités provinciaux et mécanismes de dissémination des connaissances. À partir des programmes de sélection des plantes de la Direction générale, 20 nouveaux cultivars ont été homologués et diffusés en 1984. Pour la première fois, trois semis de pommes de terre ont été, de façon concurrentielle, offerts en "exclusivité" à des compagnies commerciales, essentiellement pour la vente de semences à l'étranger. De plus, le premier type de blé triple-M (quantité moyenne de protéines, gluten de force moyenne, grain de vitrosité moyenne), HY-320, a été homologué pour la production au Canada. À la suite d'une recherche approfondie et de longues négociations, le colza canola canadien a été reconnu, aux États-Unis, comme étant un produit généralement réputé sain; cette culture a maintenant accès à des marchés intéressants et prometteurs.

Les prochaines sections du présent rapport contiennent des listes du personnel de la recherche et de la gestion, des résultats de recherches et des publications pour tous les établissements, par région, au sein de la Direction générale de la recherche.

E.J. LeRoux
Sous-ministre adjoint à la Recherche

Headquarters
Administration centrale

BRANCH EXECUTIVE
HAUTE DIRECTION

Assistant Deputy Minister, Research ***Sous-ministre adjoint à la Recherche***	E.J. LeRoux, BA, MSc, PhD

Directors General ***Directeurs généraux***

Program Coordination *Coordination des programmes*	R.L. Halstead, BSA, PhD
Institutes *Instituts*	J.W. Morrison, BSc, MSc, PhD
Atlantic Region *Région de l'Atlantique*	E.E. Lister, BSc, MSc, PhD
Quebec Region *Région du Québec*	J.-J. Jasmin, BSc(Agr), MSc
Ontario Region *Région de l'Ontario*	J.J. Cartier, BA, BSc, PhD
Prairie Region *Région des Prairies*	W.L. Pelton, BSA, MSA, PhD
Pacific Region *Région du Pacifique*	S.C. Thompson, BSc, MSA, PhD

Special Advisers ***Conseillers spéciaux***

Senior Adviser, special projects *Conseiller principal aux projets spéciaux*	J.E. Andrews, BSA, MSA, PhD
Special projects *Projets spéciaux*	Y. Bélanger, BSc
Director, Administration Division *Directeur de l'Administration*	L.R. Radburn, ACBA, RIA
Branch Financial Manager *Gestionnaire financier de la Direction générale*	J.E. Renaud, CD
Executive Assistant *Adjoint exécutif*	W. Baier, Diplomlandwirt, DrAgr, MSc

E.J. LeRoux

R.L. Halstead

J.W. Morrison

E.E. Lister

J.-J. Jasmin

J.J. Cartier

W.L. Pelton

S.C. Thompson

J.E. Andrews

Y. Bélanger

L.R. Radburn

J.E. Renaud

W. Baier

PROGRAM COORDINATION DIRECTORATE
DIRECTION DE LA COORDINATION DES PROGRAMMES

R.L. Halstead

R. Bouchard

J.R. Aitken

W.J. Saidak

D.F. Wood

D.F. Kirkland

C.J. Bishop

R.M. Prentice

R. Trottier

J. Nowland

Director general ***Directeur général*** — R.L. Halstead, BSA, PhD

Research Coordinators *Coordonnateurs des recherches*

Animals *Animaux*	R. Bouchard, BA, BSA, MSc, PhD
Contracts Analyst *Analyste de contrats*	J.R. Aitken, BSA, MSc, PhD
Crops *Cultures*	W.J. Saidak, BSA, MS, PhD
Food, Acting *Aliments, intérimaire*	D.F. Wood, BSc, MSc, PhD
International R & D, acting *R et D international, intérimaire*	D.F. Kirkland
Production *Production*	C.J. Bishop, BSc, AM, PhD, DSc, FRSC, FASHS, FAIC
Protection *Protection*	R.M. Prentice, BSc, MSc
Protection *Protection*	R. Trottier, BSc, MSc, PhD
Resources, Acting *Ressources, intérimaire*	J. Nowland, BA, MSc

Special Advisers *Conseillers spéciaux*

Animals *Animaux*	J.R. Lessard, BA, BSc, MS, PhD
Horticulture *Horticulture*	G.L. Rousselle, BA, BSc(Agr), MSc, PhD
International R & D *R et D international*	J. Millete, BSc, MSc, PhD
Production *Production*	J. Mulders, BA, BSc, MS, PhD
Production *Production*	C.B. Willis, BSc(Agr), PhD
Program accountability *Imputabilité des programmes*	J.A. Perrin, BSc
Program analysis *Analyse des programmes*	K.W. Lievers, BSc, MSc
Protection *Protection*	B.N.A. Hudson, BSc, PhD
Resources *Ressources*	M.K. John, BSc(Ag), MS, PhD

ADMINISTRATION DIVISION
DIVISION DE L'ADMINISTRATION

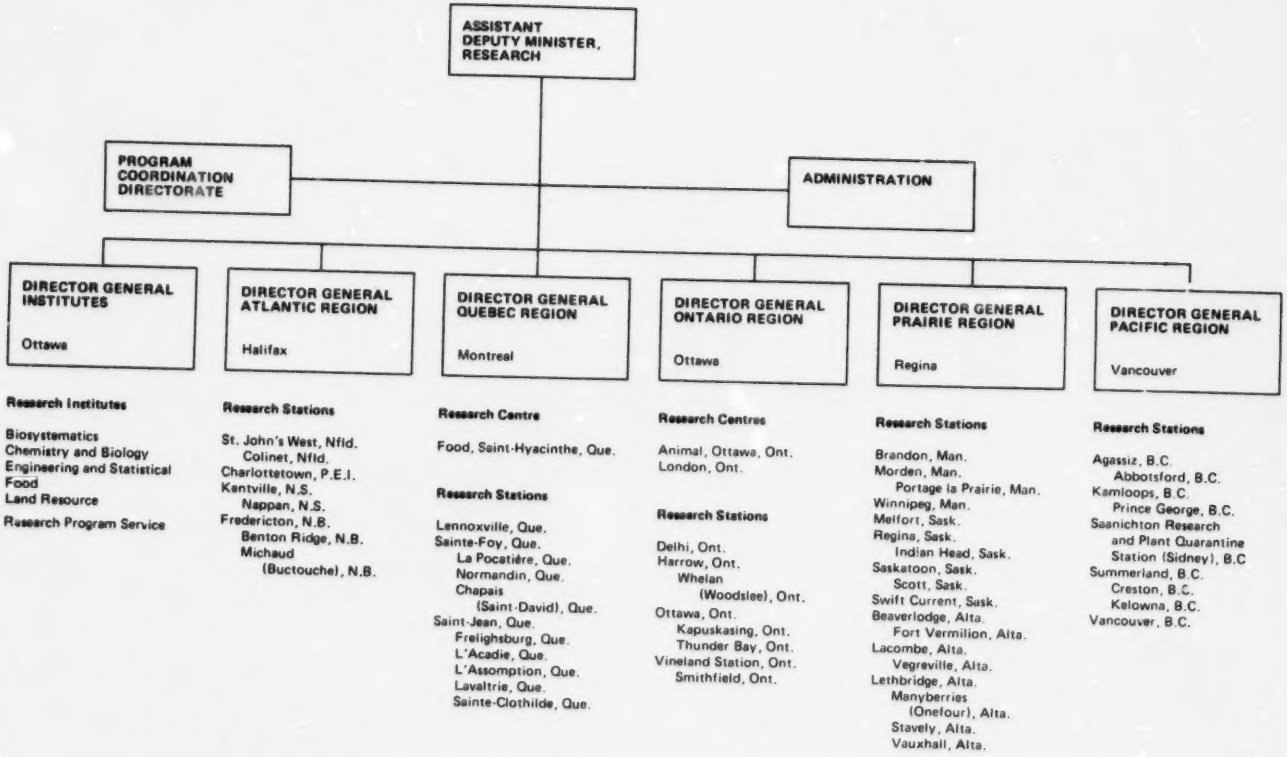
Director *Directeur*	L.R. Radburn
Chief, Administration Section *Chef de la Section de l'administration*	R. Labelle
Chief, Personnel Section *Chef de la Section du personnel*	G.J. Redmond

BRANCH FINANCIAL MANAGEMENT
GESTION FINANCIÈRE DE LA DIRECTION GÉNÉRALE

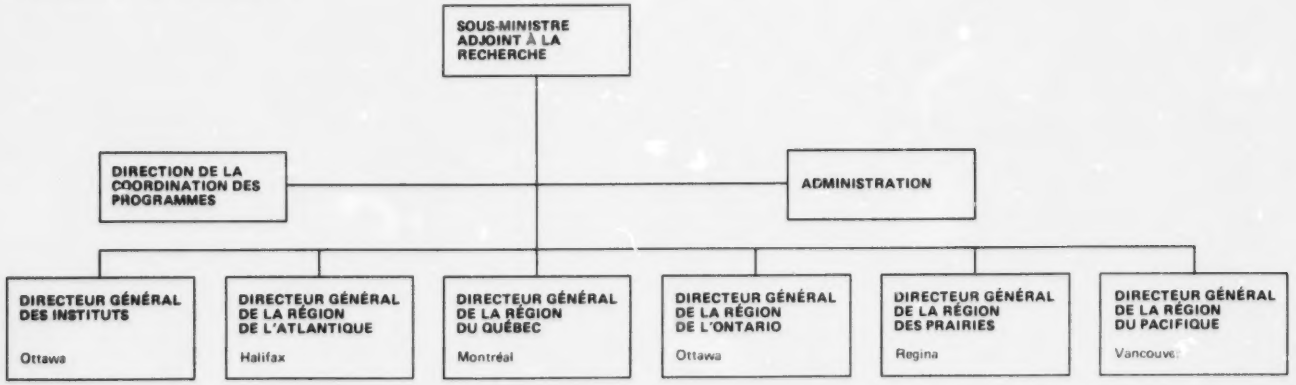
Manager *Gestionnaire*	J.E. Renaud,[1] CD
Chief, Financial planning *Chef de la Planification financière*	K. Archer,[1] RIA
Chief, Financial analysis *Chef de l'Analyse financière*	A.L. Dignard[1]
Chief, Financial planning and analysis (Institutes and Ontario) *Chef de la Planification et de l'Analyse financières (Instituts et Ontario)*	J.B. Moran[1]

[1]Seconded from Finance and Administration Branch *Détaché de la Direction générale des finances et de l'administration.*

ORGANIZATION OF THE RESEARCH BRANCH



ORGANISATION DE LA DIRECTION GÉNÉRALE DE LA RECHERCHE



Instituts de recherches

Aliments
Biocystématique
Chimie et biologie
Technique et statistique
Terres

Service aux programmes de recherche

Stations de recherches

Saint-Jean (T.-N.)
Colinet (T.-N.)
Charlottetown (Î.-P.-É.)
Kentville (N.-É.)
Nappan (N.-É.)
Fredericton (N.-B.)
Benton Ridge (N.-B.)
Michaud (Buctouche) (N.-B.)

Centre de recherches

Aliments (Saint-Hyacinthe) (Québec)

Stations de recherches

Lennoxville (Québec)
Sainte-Foy (Québec)
La Pocatière (Québec)
Normandin (Québec)
Chapais (Saint-David) (Québec)
Saint-Jean (Québec)
Frelighsburg (Québec)
L'Acadie (Québec)
L'assomption (Québec)
Lavaltrie (Québec)
Sainte-Clothilde (Québec)

Centres de recherches

London (Ont.)
Zootechnie (Ottawa) (Ont.)

Stations de recherches

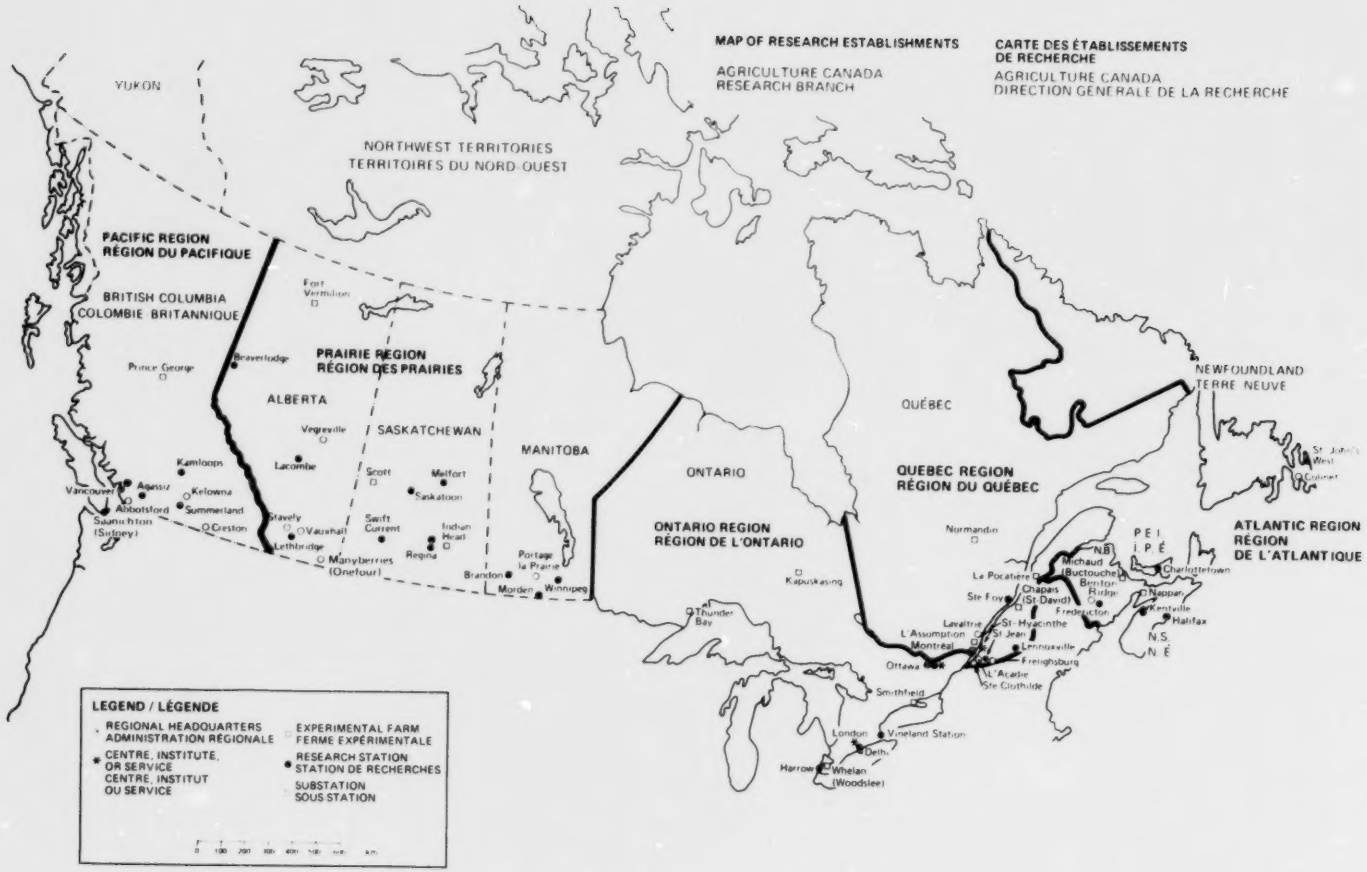
Delhi (Ont.)
Harrow (Ont.)
Whelan (Woodslee), (Ont.)
Ottawa (Ont.)
Kapuskasing (Ont.)
Thunder Bay (Ont.)
Vineland Station (Ont.)
Smithfield (Ont.)

Stations de recherches

Brandon (Man.)
Morden (Man.)
Portage-la-Prairie (Man.)
Winnipeg (Man.)
Melfort (Sask.)
Regina (Sask.)
Indian Head (Sask.)
Saskatoon (Sask.)
Scott (Sask.)
Swift Current (Sask.)
Beaverlodge (Alb.)
Fort Vermilion (Alb.)
Lacombe (Alb.)
Végreville (Alb.)
Lethbridge (Alb.)
Manyberries (Onefour) (Alb.)
Stavely (Alb.)
Vauxhall (Alb.)

Stations de recherches

Agassiz (C.-B.)
Abbotsford (C.-B.)
Kamloops (C.-B.)
Prince George (C.-B.)
Station de recherches et de quarantaine des plantes de Saanichton (Sidney) (C.-B.)
Summerland (C.-B.)
Creston (C.-B.)
Kelowna (C.-B.)
Vancouver (C.-B.)


MAP OF RESEARCH ESTABLISHMENTS
AGRICULTURE CANADA
RESEARCH BRANCH
CARTE DES ÉTABLISSEMENTS DE RECHERCHE
AGRICULTURE CANADA
DIRECTION GÉNÉRALE DE LA RECHERCHE
YUKON
NORTHWEST TERRITORIES
TERRITOIRES DU NORD-OUEST
PACIFIC REGION
RÉGION DU PACIFIQUE
BRITISH COLUMBIA
COLOMBIE-BRITANNIQUE
PRAIRIE REGION
RÉGION DES PRAIRIES
ALBERTA
SASKATCHEWAN
MANITOBA
ONTARIO
ONTARIO REGION
RÉGION DE L'ONTARIO
QUÉBEC
QUEBEC REGION
RÉGION DU QUÉBEC
NEWFOUNDLAND
TERRE NEUVE
ATLANTIC REGION
RÉGION DE L'ATLANTIQUE
P.E.I.
I.P.É.
N.S.
N.É.
Fort Vermilion
Prince George
Beaverlodge
Vegreville
Lacombe
Scott
Melfort
Saskatoon
Swift Current
Indian Head
Regina
Manyberries (Onefour)
Stavely
Vaushall
Lethbridge
Kamloops
Agassiz
Kelowna
Summerland
Creston
Vancouver
Abbotsford
Saanichton (Sidney)
Brandon
Morden
Winnipeg
Portage la Prairie
Thunder Bay
Kapuskasing
Normandin
La Pocatière
Ste Foy
Chapais
(St David)
Richaud
Buctouche
Benton
Ridge
Fredericton
Nappan
Kentville
Halifax
Charlottetown
Lavaltrie
L'Assomption
Montreal
St-Hyacinthe
St Jean
Lennoxville
Ottawa
Frelighsburg
L'Acadie
Ste Clothilde
Smithfield
London
Vineland Station
Delhi
Harrow
Whelan
(Woodslee)
St John's West
Gaultois
LEGEND / LÉGENDE
REGIONAL HEADQUARTERS
ADMINISTRATION RÉGIONALE
CENTRE, INSTITUTE, OR SERVICE
CENTRE, INSTITUT OU SERVICE
EXPERIMENTAL FARM
FERME EXPÉRIMENTALE
RESEARCH STATION
STATION DE RECHERCHES
SUBSTATION
SOUS-STATION

PROGRAM STRUCTURE OF THE RESEARCH BRANCH

Departmental objective

Agriculture Canada's objective is to promote the growth, stability, and competitiveness of the agri-food sector, by making available policies, programs, and services that are most appropriately provided by the federal government, so that the sector makes its maximum contribution to the economy.

Branch objective

The Research Branch's objective for the scientific research and development planning element is to maintain and improve the productivity of the agri-food sector through developing and transferring new knowledge and technology.

Objectives for branch planning sub-elements and sub-sub-elements

Management and administration. To provide the managerial, financial, personnel, and administrative services required for efficient management of the Research Branch.

1. Planning and program management
   To provide branch planning and program coordination in support of senior branch management.
2. Administrative services
   To provide support for branch management in financial, personnel, and any other administrative areas necessary for the efficient functioning of the branch.

Resource and support research. To produce scientific and technical information and to develop technology that will assist the agri-food sector in managing and conserving the natural resources necessary for agricultural production, while increasing the level and efficiency of production, and that will assist other researchers in developing applied technology.

1. Land
   To provide accurate information about the quantity, quality, and location of Canada's land resource and to better understand the properties of soils, which affect agricultural productivity.
2. Water and climate
   To improve water management on Canadian soils in order to increase productivity and to monitor and preserve environmental quality within the constraints imposed by Canada's northern climate.
3. Energy and engineering
   To develop and adapt engineering technology that will optimize energy utilization and efficiency of production, storage, processing, and distribution of agricultural products.
4. Biological resources
   To provide accurate information about the quantity, quality, and location of Canada's biological resources (including vascular plants, insects, arachnids, nematodes, fungi, and bacteria) and to provide identification services that can be used as required to ensure agricultural productivity.
5. Biotechnology
   To assess, develop, and utilize technology in support of basic and applied agricultural research.
6. Protection
   To provide new, general, and basic research information on the protection of animals and crops from diseases, insects, and weeds.
7. Scientific support services
   To provide for all scientific researchers the analytical, statistical, graphic arts, publishing, and other general support services necessary to maintain the quality and quantity of output of research findings.

Animal productivity research. To produce scientific and technical information and develop new technology that will assist the primary producer in increasing the quality and efficiency of the production of animals.

1. Beef
   To improve the efficiency of beef production and the quality of beef products in support of regional, domestic, and export market development.
2. Dairy
   To improve the efficiency of milk production for domestic and export market development.
3. Swine
   To improve the efficiency of pork production and the quality of pork and pork products in support of domestic and export market development.
4. Poultry
   To improve the efficiency of production of eggs and poultry meat and the quality of poultry products in support of domestic and export market development.
5. Other animals
   To increase the efficiency of production and

quality of products from sheep, honey bees, fur bearers, and any other animals deemed to be of agricultural importance in support of domestic and export market development.

Crop productivity research. To produce scientific and technical information and develop new technology that will assist the primary producer in increasing the quality and efficiency of the production of crops.

1. Cereals
   To increase the production efficiency, quality, and protection of cereal crops for domestic and export markets.
2. Oilseeds
   To increase the efficiency of production adaptability and the quality of oilseed crops and their products for domestic and export markets.
3. Forages
   To increase the efficiency of production adaptability and the quality of domestic forage crops in support of livestock production.
4. Field crops
   To increase the production efficiency, quality, and protection of field crops such as tobacco, field peas, buckwheat, and field beans.
5. Vegetables
   To increase the efficiency of production, protection, adaptability, and quality of vegetables for the domestic market, and of potatoes and seed potatoes for export.
6. Tree fruits and berries
   To increase the efficiency of production, protection, adaptability, and quality of tree fruits and berries for domestic and export markets.
7. Ornamentals
   To develop, test, and release high-quality ornamental plants that are adapted to Canada's climatic regions.

Food research. To produce scientific and technical information and develop technology that will assist the agri-food processing sector in increasing the efficiency and effectiveness of crop and animal commodity processing, while ensuring the safety and nutritional value of food.

1. Crop processing and products
   To develop new food-processing technology, to improve the efficiency and effectiveness of food-processing systems, and to develop and characterize new products and ingredients in the processing of agricultural crops.
2. Livestock processing and products
   To develop new food-processing technology, to improve the efficiency and effectiveness of food-processing systems, and to develop and characterize new products and ingredients in the processing of animal and dairy products.
3. Food safety and nutrition
   To increase consumer safety from antinutritional and toxic constituents in food and to improve the nutritive value of processed foods, where practical, in order to improve the level of nutrition of Canadians.

STRUCTURE DU PROGRAMME DE LA DIRECTION GÉNÉRALE DE LA RECHERCHE

Objectif du Ministère

L'objectif d'Agriculture Canada est de promouvoir la croissance, la stabilité et la compétitivité du secteur agro-alimentaire au moyen de politiques, de programmes et de services fournis par le gouvernement fédéral, de façon à assurer une contribution optimale de ce secteur à l'économie.

Objectifs de la Direction générale

L'élément planification de la recherche scientifique et du développement de la Direction générale de la recherche a pour objectif d'améliorer la productivité du secteur agro-alimentaire en mettant au point de nouvelles technologies et en diffusant les connaissances.

Objectifs des sous-divisions et des sub-sous-divisions de la planification

Gestion et administration. Fournir les services nécessaires dans les domaines de la gestion, des finances, du personnel et de l'administration afin d'assurer une gestion efficace de la Direction générale.

1. Planification et gestion des programmes
   Assurer la planification et la coordination des programmes de la Direction générale afin d'appuyer la haute direction.
2. Services administratifs
   Fournir un soutien à la haute direction dans les domaines des finances, du personnel et tout autre domaine administratif pour assurer le bon fonctionnement de la Direction générale.

Recherche sur les ressources et recherche de soutien. Mettre à la disposition du secteur agro-alimentaire des informations scientifiques et techniques et développer des technologies qui l'aideront à gérer et à conserver les ressources naturelles nécessaires à la production agricole tout en augmentant leur utilisation efficace: ces

mêmes ressources doivent aider les chercheurs à mettre au point des technologies appliquées.

1. Terres
   Fournir des informations précises sur la quantité, la qualité et l'emplacement des ressources en terres du Canada et parvenir à une meilleure connaissance des propriétés des sols, qui influent sur la productivité agricole.
2. Eau et climat
   Améliorer la gestion des eaux sur les sols du Canada afin d'accroître la productivité et de contrôler et conserver la qualité de l'environnement, en tenant compte des contraintes imposées par le climat boréal du Canada.
3. Énergie et recherches techniques
   Développer et adapter une technologie pour optimiser le rendement énergétique et l'efficacité de la production, du stockage, de la transformation et de la distribution des produits agricoles.
4. Ressources biologiques
   Fournir des informations précises sur la quantité, la qualité et l'emplacement des ressources biologiques du Canada (notamment les plantes vasculaires, insectes, arachnides, nématodes, champignons et bactéries) et offrir des services d'identification sur demande pour assurer la productivité agricole.
5. Biotechnologie
   Évaluer, développer et appliquer une technologie à l'appui de la recherche agricole fondamentale et appliquée.
6. Protection
   Fournir les résultats généraux et fondamentaux sur la recherche dans le domaine de la protection des animaux et des récoltes contre les maladies, les insectes et les mauvaises herbes.
7. Services de soutien scientifique
   Fournir à tous les chercheurs des statistiques, des données analytiques, des publications et tout autre service d'aide générale nécessaire au maintien de la qualité de la recherche et à l'accroissement de la productivité des opérations.

Recherche sur la production animale. Produire l'information scientifique et technique et élaborer une nouvelle technologie afin d'aider le producteur primaire à augmenter la qualité et l'efficacité de la production animale.

1. Bovins de boucherie
   Accroître l'efficacité de la production bovine et améliorer la qualité des produits pour les marchés régional, national et d'exportation.
2. Bovins laitiers
   Accroître l'efficacité de la production laitière pour les marchés national et d'exportation.
3. Porcs
   Accroître l'efficacité de la production porcine et améliorer la qualité des produits pour les marchés national et d'exportation.
4. Volaille
   Accroître l'efficacité de la production des oeufs et de la volaille et améliorer la qualité des produits avicoles pour les marchés national et d'exportation.
5. Autres
   Accroître l'efficacité de la production ovine, apicole, d'animaux à fourrure et de tous les autres animaux jugés importants pour l'agriculture, pour les marchés national et d'exportation.

Recherche sur les productions végétales. Produire de l'information scientifique et technique et élaborer une nouvelle technologie afin d'aider le producteur primaire à augmenter la qualité et l'efficacité de la production animale.

1. Céréales
   Accroître l'efficacité, la qualité et la protection des cultures cerealières pour les marchés national et d'exportation.
2. Oléagineux
   Accroître l'adaptabilité sur le plan productif et la qualité des oléagineux et de leurs produits pour les marchés national et d'exportation.
3. Fourrages
   Accroître l'adaptabilité sur le plan productif et la qualité des cultures fourragères national afin d'aider à la production du bétail.
4. Grandes cultures
   Accroître l'efficacité de la production, la qualité et la protection des grandes cultures comme le tabac, le pois sec, le sarrasin et le haricot sec.
5. Légumes
   Accroître l'efficacité de la production, la protection, l'adaptabilité et la qualité des légumes pour le marché national, et des pommes de terre et des pommes de terre de semence pour l'exportation.
6. Arbres fruitiers et baies
   Accroître l'efficacité de la production, la protection, l'adaptabilité et la qualité des arbres fruitiers et des baies afin d'augmenter les marchés national et d'exportation.

7. Plantes d'ornement
   Développer, tester et distribuer des plantes d'ornement de grande qualité qui soient adaptées aux différentes régions climatiques du Canada.

Recherches alimentaires. Fournir l'information scientifique et technique et élaborer la technologie à l'appui du secteur de la transformation agro-alimentaire afin d'accroître l'efficacité et la rentabilité de la transformation des produits animaux et végétaux tout en assurant la salubrité et la valeur nutritive des aliments produits.

1. Transformation alimentaire et aliments
   Élaborer de nouvelles techniques de transformation alimentaire des produits végétaux, accroître l'efficacité et la rentabilité du système et élaborer et caractériser de nouveaux produits et ingrédients.
2. Transformation du bétail et produits alimentaires
   Élaborer de nouvelles techniques de transformation alimentaire des produits animaux, accroître l'efficacité et la rentabilité du système et élaborer et caractériser de nouveaux produits et ingrédients.
3. Salubrité des aliments et nutrition
   Accroître la protection des consommateurs contre les constituants alimentaires toxiques et néfastes sur le plan nutritif et rehausser si possible, la valeur nutritive des aliments transformés afin d'assurer une meilleure nutrition aux Canadiens.

Institutes Directorate
Direction des Instituts

J.W. Morrison

G. Poushinsky

D.G. Proctor

Director General *Directeur général*	J.W. Morrison, BSc, MSc, PhD
Program Specialist *Spécialiste en programmes*	G. Poushinsky, BSc, MSc
Chief, Administration *Chef de l'administration*	D.G. Proctor

PREFACE

The Institutes Directorate, located at the Central Experimental Farm in Ottawa, consists of the Biosystematics Research Institute (BRI), the Chemistry and Biology Research Institute (CBRI), the Engineering and Statistical Research Institute (ESRI), the Food Research Institute (FRI), the Land Resource Research Institute (LRRI), and Research Program Service (RPS). In 1984 the institutes' programs were conducted by a staff of 582 with a budget of approximately $40 million. All the institutes combine active research on national programs with service to regional stations or to the public in specialized areas of their research.

The BRI provides Agriculture Canada, other departments and agencies, and their clients with a unique center of systematic expertise for dealing with economic and social problems relating to insects, mites, spiders, plant parasitic nematodes, weeds, crop plants, native plants, plant parasitic and biodegrading fungi, and nonmedical bacteria. Its comprehensive collections, identification expertise, and systematic research capability enable BRI to provide all systematic services to support production and resource protection for two major Canadian industries, agriculture and forestry.

The CBRI concentrates on biotechnology, preservation of natural resources, environmental protection, and food safety. Some of the applications in these areas are nitrogen fixation, mycotoxin research, and stress physiology. It also provides services in analytical chemistry and electron microscopy to other Branch establishments.

The personnel of ESRI continue to provide consultation in support of all departmental objectives. The engineering group focuses on energy, food engineering, structures, mechanization, instrumentation, and equipment development. The statistical group continues to research new methodology and to provide computer software for statistical analysis.

The aim of FRI is to assist the Canadian food industry to become more efficient, productive, and competitive by developing new processes and prototype ingredients and improving the quality, safety, and nutritional value of foods. This year a mechanism for direct consultation with the food industry was initiated through an industry liaison committee and through discussions with industry technical committees on specific commodities. The in-house research programs on dairy products, oil seeds, meats, food safety, and nutrition are geared to the needs of the food industry and the concerns of the consumer.

Responsibility for national programs in land resources and agrometeorologic services resides in LRRI. The programs of the institute include the national soil survey; a supporting role in soil classification; studies in land evaluation, agricultural land use, and soil degradation; and agrometeorological services, a farm weather service, crop-weather modeling, and a crop information system.

The RPS provides a variety of specialized services nationwide to Research Branch establishments and in support of Canadian agricultural research at the university, provincial, and federal levels.

The institutes maintain strong links with the private sector. A notable mechanism for this is the contracting programs. The major funds administered by the institutes include energy (ERDAF), toxic chemicals, human nutrition, processing distribution and retailing (PDR), crop information, and land evaluation.

Further information about our programs may be obtained by writing to the research establishments concerned or by addressing enquiries to Institutes, Research Branch, Agriculture Canada, Room 2077, K.W. Neatby Building, Ottawa, Ont. K1A 0C6.

J.W. Morrison
Director General

PRÉFACE

La Direction des instituts, située à la Ferme expérimentale centrale d'Ottawa, comprend l'Institut de recherches biosystématiques (IRB), l'Institut de recherches chimiques et biologiques (IRCB), l'Institut de recherches techniques et de statistiques (IRTS), l'Institut de recherches sur les aliments (IRA), l'Institut de recherches sur les terres (IRT) et le Service aux programmes de recherches (SPR). En 1984, un effectif de 582 employés a réalisé les divers programmes de l'Institut, à l'aide d'un budget d'environ 40 millions de dollars. Tous les instituts accomplissent à la fois des activités de recherches dans le cadre des programmes nationaux et offrent des services dans leurs spécialités respectives aux stations régionales ou au grand public.

L'IRB constitue, pour Agriculture Canada, pour d'autres ministères et organismes et pour leurs clients, un centre unique de connaissances spécialisées dans l'étude des problèmes économiques et sociaux reliés aux insectes, aux acariens, aux araignées, aux nématodes parasites des plantes, aux mauvaises herbes, aux plantes cultivées, aux plantes indigènes, aux champignons parasites des plantes et biodégradants, et aux bactéries sans intérêt médical. Grâce à ses collections complètes, à son service d'identification et à sa capacité de recherches en systématique, l'IRB est en mesure de dispenser aux deux grandes industries canadiennes que sont l'agriculture et les forêts tous les services pertinents nécessaires dans le cadre de la production et de la protection des ressources.

L'IRCB se concentre sur la biotechnologie, la conservation des ressources naturelles, la protection de l'environnement et la salubrité des aliments. La fixation de l'azote, les mycotoxines et la physiologie du stress retiennent surtout l'attention. L'Institut procure en outre des services de chimie analytique et de microscopie électronique aux autres établissements de la Direction générale.

Le personnel de l'IRTS continue à donner des conseils qui contribuent à la réalisation des objectifs du Ministère. Le groupe technique s'intéresse aux domaines de l'énergie, du génie alimentaire, de la construction, de la mécanisation, de l'appareillage et de la conception de matériel. Le groupe de la statistique continue à mettre au point de nouvelles méthodes et à créer des logiciels pour l'analyse statistique.

L'IRA a pour mandat d'aider l'industrie alimentaire canadienne à devenir plus efficace, plus productive et plus compétitive en mettant au point de nouveaux procédés et ingrédients, ainsi qu'en augmentant la qualité, la salubrité et la valeur nutritionnelle des aliments. En 1984, on a mis en place un mécanisme de consultation directe avec le secteur de l'alimentation, en créant un comité de liaison profession-État et en établissant des échanges sur des produits précis avec des comités techniques du secteur. Les programmes de recherches internes qui traitent des produits laitiers, des plantes oléagineuses, de la viande, de la salubrité des aliments et de la nutrition tiennent compte des besoins de l'industrie alimentaire et des préoccupations des consommateurs.

L'IRT est chargée de l'exécution des programmes nationaux dans les domaines des ressources en terres et des services agro-météorologiques. Parmi les programmes de l'Institut figurent notamment l'inventaire national des sols; la participation à la classification des sols; des études sur l'évaluation des terres, l'utilisation des terres agricoles et la dégradation des sols; les services agro-météorologiques, les services de renseignements météorologiques aux agriculteurs, la construction de modèles agroclimatiques et un système d'information sur les cultures.

Le SPR offre une variété de services spécialisés aux établissements de la Direction générale de la recherche et aux chercheurs en agriculture, aux échelons universitaire, provincial et fédéral.

Les instituts entretiennent des liens étroits avec le secteur privé, notamment grâce au mécanisme d'impartition des recherches. Les instituts administrent entre autres les grandes enveloppes de l'énergie (programme de recherche et de développement énergétiques en agriculture et en alimentation); des produits chimiques toxiques; de la nutrition humaine; de la transformation, de la distribution et de la vente au détail des aliments; de l'information sur les cultures et de l'évaluation des terres.

Pour de plus amples renseignements sur nos programmes, veuillez écrire aux établissements de recherches concernés ou aux instituts, Direction générale de la recherche, Agriculture Canada, pièce 2077, édifice K.W. Neatby, Ottawa (Ont.), K1A 0C6.

J.W. Morrison
Directeur général

Biosystematics Research Institute, Ottawa, Ontario

PROFESSIONAL STAFF

G.A. Mulligan, BSc	Director
I.M. Smith, BSc, PhD	Assistant Director
E. Gavora,[1] ING, BLS	Librarian, Botany
M.-J. Boisvenue,[1] BSc, M Bibl	Librarian, Entomology
J.E.H. Martin	Manager, National Identification Service, Zoology; Unit Curator of Miscellaneous Insect Orders
P.M. LeClair	Manager, National Identification Service, Botany
A. Giroux	Administrative Officer

Nematodes and Hemiptera

R.V. Anderson, BA, MS, PhD	Head of Section; Unit Curator of Nematodes; Hoplolaimidae (spiral nematodes), Tylenchorhynchidae (stylet nematodes), Aphelenchoidea (foliar nematodes)
B.A. Ebsary, BSc, MSc, PhD	Criconematidae (ring nematodes), Hemicycliophoridae (sheath nematodes)
R.G. Foottit, BSA, MSc, PhD	Unit Curator of Hemiptera; Aphids, scales, and thrips
K.G.A. Hamilton, BSA, MSc, PhD	Cicadellidae (leafhoppers), Cercopidae (spittlebugs)

Hymenoptera

M.J. Sharkey, BSc, MSc, PhD	Head of Section; Braconidae (braconid wasps)
J.R. Barron, BSc, MSc, PhD	Ichneumonidae
G.A.P. Gibson, BSc, MSc	Chalcidoidea (chalcid wasps)
H. Goulet, BA, BSc, MSc, PhD	Symphyta (sawflies)
L. Masner, BSc, MSc, PhD	Proctotrupoidea (proctotrupid wasps), Sphecoidea (digger wasps), Evanioidea (ensign wasps); Unit Curator of Hymenoptera
W.R.M. Mason, BSc, PhD	Braconidae (braconid wasps)
C.M. Yoshimoto,[2] BA, MSc, PhD	Chalcidoidea (chalcid wasps), Cynipoidea (gall wasps)

Diptera

A. Borkent, BSc, MSc, PhD	Cecidomyiidae (gall midges), Ceratopogonidae (biting midges)
J.F. McAlpine, BSA, MSc, PhD	Lonchaeidae (lance flies), Chamaemyiidae (silver flies)
H.J. Teskey, BSc, MSA, PhD	Unit Curator for Diptera; Tabanidae (horse flies and deer flies)

J.R. Vockeroth, BA, MA, D Phil	Syrphidae (flower flies), Scatophagidae (dung flies)
D.M. Wood, BA, MA, PhD	Tachinidae (parasitic flies), Culicidae (mosquitoes)

Coleoptera

J.M. Campbell, BSc, MS, PhD	Head of Section; Staphylinidae (rove beetles)
Y. Bousquet, BSc, MSc, PhD	Colydiidae, Elateridae (click beetles and wire worms), other stored-products beetles
D.E. Bright, BSc, MSc, PhD	Scolytidae (bark beetles), Curculionidae (weevils)
L. LeSage, BSc, MSc, PhD	Chrysomelidae (leaf beetles)
A. Smetana, M U DR, Cand Sc Biol	Aquatic beetles, Staphylinidae (rove beetles); Unit Curator of Coleoptera

Arachnida and Insect Biology

C.D. Dondale, BSc, MSc, PhD	Head of Section; Araneae (spiders), Opiliones (harvestmen)
V.M. Behan-Pelletier, BSc, MSc, PhD	Oribatei (oribatid mites); Unit Curator of Arachnida
E.E. Lindquist, BSc, MSc, PhD	Acari (mites and ticks)
R. Matsuda, BA, PhD, DSc	Comparative morphology and evolution
D.R. Oliver, BA, MA, PhD	Chironomidae (chironomid midges)
I.M. Smith, BSc, PhD	Eriophyoidea (rust and gall mites), Hydrachnida (water mites)

Lepidoptera and Trichoptera

J.D. Lafontaine, BA, MS, PhD	Head of Section; Noctuidae (cutworm moths); Unit Curator of Lepidoptera and Trichoptera
S.A. Allyson, BSc, MSc	Lepidopterous larvae (caterpillars)
P.T. Dang,[2] BSc, MS, PhD	Microlepidoptera of forest importance (spruce budworm)
J.F. Landry, MSc	Microlepidoptera of agricultural importance
A. Mutuura, BSc, PhD	Tortricidae (leafroller moths)
F. Schmid, Lic ès Sc Nat, D ès Sc Nat	Trichoptera (caddisflies)

Mycology

G.A. Neish, BSc, PhD	Head of Section; Mycotoxin fungi
D.J.S. Barr, BSc, MSc, PhD	Curator of National Collection of Fungus Cultures; zoosporic parasites of vegetable crops
J.D. Bissett, BSc, PhD	Conidial parasites of forage crops
M.P. Corlett, BA, MA, PhD	Ascocarpic parasites of fruit crops
Y. Dalpé, BSc, MSc, DSc	Mycorrhizae
J.H. Ginns, BSc, MSc, PhD	Basidiocarpic tree wood rots
S.A. Needham,[3] BA, BSc	Curator of the National Culture Collection of Fungi and Nonmedical Bacteria

J.A. Parmelee, BSc, MA, PhD	Obligate parasites of plants (rusts, smuts, mildews); Curator of National Mycological Herbarium
S.A. Redhead, BSc, MSc, PhD	Mushrooms
R.A. Shoemaker, BSA, MSA, PhD	Ascocarpic parasites of cereals

Vascular Plants

B.R. Baum, MSc, PhD, FRSC	Head of Section; Cultivated crops, *Hordeum*
G. Baillargeon, BSA, MSc	Cultivated crops, *Brassica*
I.J. Bassett, BA	Hay-fever plants, palynology, weeds
J. Cayouette,[4] MTh, MSc, PhD	Grass flora of Canada
C.W. Crompton, MSc	Weed biology—taxonomy and palynology
W.J. Cody, BA	Curator of Herbarium; Canadian flora, ferns
G.A. Mulligan, BSc	Weeds, Cruciferae
E. Small, BA, BSc, MSc	Cultivated crops, *Medicago*
A.E. Stahevitch, BSc, MSc, PhD	Weeds, cytotaxonomy
S.I. Warwick, BSc, PhD	Weeds, genecology

Honorary Research Associates

E.C. Becker, BSc, MSc, PhD	Elateridae (click beetles, wireworms)
J.A. Downes, BSc	Ceratopogonidae (biting midges)
G.P. Holland, BA, MA, DSc, FRSC	Siphonaptera (fleas)
S.J. Hughes, BSc, MSc, DSc, FLS, FRSC	Conidial molds of wood and insects
L.A. Kelton, BSA, MSc, PhD	Miridae (plant bugs), Anthocoridae (flower bugs)
W.C. McGuffin, BA, MA, PhD	Geometridae (geometer moths, loopers)
D.B.O. Savile, BSA, MSc, PhD, DSc, FRSC	Plant rusts
G.E. Shewell, BSc, MSc	Lauxaniidae (lauxaniid flies), Calliphoridae (blow flies)

Departures

S.G. Aiken, BSc, MSc, PhD	Grass flora of Canada
B.N.A. Hudson, BSc, PhD Seconded, Research Branch Coordinator Group	Chemical taxonomy of insects, polymorphic enzymes
L.A. Kelton, BSA, MSc, PhD Retired	Miridae (plant bugs), Anthocoridae (flower bugs)
P.J. Purcell-Smith, BA, MLS	Librarian, Entomology

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[1]Seconded from Libraries Division, Finance and Administration Branch.
[2]Seconded from Canadian Forestry Service Branch of Agriculture Canada.
[3]Appointed October 1984.
[4]Appointed December 1984.

INTRODUCTION

The Biosystematics Research Institute (BRI) provides Agriculture Canada, other departments and agencies, and their clients with a unique center of systematic expertise for dealing with economic and social problems relating to insects, mites, spiders, plant parasitic nematodes, weeds, crop plants, native plants, plant parasitic and biodegrading fungi, and nonmedical bacteria. It provides Canadians with an expert team of scientists and technicians that maintains and updates an information system ensuring that the identities of any of these organisms can be determined accurately and that appropriate data on their biology and impact are quickly available. It is a vehicle for the flow of biosystematic information nationally and between Canada and other countries. The following broad aims guide the Biosystematics Research Institute in its operations: to conduct research to discriminate and correctly name organisms that occur in Canada or are otherwise of importance to Canadians; to contribute to science and its uses by developing natural classifications and interpreting evolutionary relationships; to develop and maintain the national collections of living or preserved organisms from Canada and elsewhere to provide a reference base for biosystematic research on diversity and distribution, and for identification purposes; to provide a national identification service for clients, publish guides to help others make identifications, and supply relevant information; to provide inventories and floristic and faunistic studies for selected regions, habitats, or host groups to permit effective assessment and monitoring of environments, their quality, and their changes; to provide leadership and cooperation in the development of biosystematics in Canada by making expertise available for training and other educational purposes.

Reprints of publications are available from the authors. Correspondence on other matters should be addressed to the Director, Biosystematics Research Institute, Research Branch, Agriculture Canada, Ottawa, Ont. K1A OC6.

G.A. Mulligan
Director

COLLECTION DEVELOPMENT AND MAINTENANCE

The holdings of the Canadian National Collection of Insects, Arachnids, and Nematodes increased by 479 400 specimens during 1984, of which 283 000 specimens were curated. Major contributions were made by members of the institute collecting throughout Canada, northern United States, Australia, and New Zealand. A team of four institute scientists spent a month in the British Mountains of the northern Yukon, an area with a rich, diverse, and previously unexplored arthropod fauna. This is part of ongoing research by institute scientists on the fauna of the Canadian Arctic and its relationship with the arctic fauna of adjacent areas. During the summer of 1984, the institute continued the survey of the insects and arachnids of Cape Breton Highlands National Park, with 19 officers of the institute participating. This was the final year of a 2-yr project, to be completed in March 1985, which is providing a large collection of specimens relevant to the research interests of the institute and, in addition, augmenting the holdings of the National Collection. Ten thousand specimens were purchased and 53 525 specimens were donated to the National Collection in 1984, consisting of material from Canada, Alaska, southern United States, Mexico, the Caribbean, South America, and India. Growth of the National Collection involved acquisition and curation of material required both for current research activities of institute scientists and for increasing representation of other groups of importance to Canadians. Requests for loaning of material from scientists throughout the world amounted to 169 loans of approximately 100 000 specimens. Many scientists and students from various parts of the world, including Australia, Mexico, and Europe, visited the Canadian National Collection in 1984 to study and curate specific groups. The CanaColl Endowment Fund supported five people, who curated several thousand specimens of Diptera, Coleoptera, Hymenoptera, and Lepidoptera. The CanaColl Development Fund, initiated in 1984

and to which Agriculture Canada generously gave $1000 in the form of a contract, supported one scientist who curated several thousand Arctic butterflies. Preparation of insect and arachnid specimens, especially those from Cape Breton Highlands National Park, was carried out with the assistance of three persons employed under the training of handicapped program and four persons employed on the homebound handicapped program. This help facilitated preparation of material that would otherwise not have been possible with our present staff. In November of this year the Minister of Communications granted the institute designation under the Cultural Property Export and Import Act for an indefinite period. The institute is now eligible to apply for cultural property tax certificates for donated or purchased specimens and library material, and for grants to assist in the purchase of cultural property.

The holdings of the Vascular Plant Herbarium now stand at 773 461, an increase of 12 559 specimens during the year. A total of 4600 plant collections were made by staff members during field trips to various parts of Canada, including the Yukon Territory. Some 1895 specimens were received on exchange from Canadian and foreign correspondents and 819 specimens were received as gifts. We received 7697 specimens in 68 loans from cooperating Canadian and foreign institutions and sent out 6159 specimens to 42 herbaria in Canada and abroad.

The National Mycological Herbarium has increased its holdings by 3107 specimens and now totals 245 383. We received 584 specimens as gifts and 439 specimens as exchange from other institutions for a total of 1023. Mycology staff sent to other institutions 350 gift specimens and 1647 exchange specimens. To examine specimens and gain other information, researchers in agriculture, forestry, universities, and industry from Canada, the United States, and Europe visited the herbarium for periods of 1 day to 2 wk.

The National Collection of Fungus Cultures increased its holdings from 8005 to 8323. The increase was due mainly to material received through the Identification Service, cultures received for deposit from other establishments, or from isolations made by staff members. At present 2794 cultures have been successfully lyophilized for long-term preservation. During 1984, 251 cultures were sent out in answer to requests from scientists in Canada and throughout the world. The institute enacted position and staff reassignments during 1984 in support of the national biotechnology research and development effort and Agriculture Canada's agri-food strategy. These changes included the appointment of a full-time curator to manage the collection. As well, new laboratory space and facilities were provided to help meet these objectives. More than 50 isolates of Boletaceae, most of them ectomycorrhizal, deposited in the National Collection of Fungus Cultures were successfully revived after 27 yr of preservation on agar under paraffin oil, indicating that long-term storage of bolete cultures is possible, using a simple inexpensive method.

NATIONAL IDENTIFICATION SERVICE

A total of 1057 shipments of insects, mites, spiders, and nematodes were received by the zoology portion of the National Identification Service during 1984 and 69 898 specimens were identified. The primary users were Agriculture Canada, including the Forestry Branch (48%), and Canadian universities (24%). The remaining clients were other federal and provincial departments and agencies, the general public, and industry. A few examples of activities supported by identification and biological information are as follows: biological control programs on gypsy moth in the Maritimes, winter moth on Vancouver Island, wheat midge in Saskatchewan, and bark beetles at Victoria; the control of insect pests in farm granaries of western Canada; a Northern Forest Research Centre pictorial guide to insects of forest and shade trees of the Canadian prairies; pest control studies of flea beetles and other insects on vegetables and small fruits at L'Assomption; the role of soil mites in a Chalk River project on the effects of clear-cutting on forest productivity; the control of debarking weevils in Nova Scotia; the role of aquatic insects in a fish habitat protection project in Halifax; insects, arachnids, and nematodes intercepted at ports of entry; pheromone research on cutworms at Lethbridge; and the use of larval diptera as an aid in determining the time of death in criminal cases.

During 1984, 10 392 collections of vascular plants were identified. Major users of the service this year were Agriculture Canada (22%), other federal departments (15%), and the general public (12%). An increased number of inquiries was received directly from the general public and through Communications Branch, Agriculture Canada. Assistance was provided on the identification of weeds, edible plants, poisonous plants, and native plants. The identifications provided to agriculture research stations and other departments related to weed control research, host plants of insect pests and pathogens, poisonings of humans and livestock, aquatic weed prob-

lems, the interception of plant materials used in commercial products imported into Canada, studies investigating waterfowl habitats, and horticultural production on various soil types. During 1984, several inquiries were received from the Forensic Laboratory of the Royal Canadian Mounted Police for the identification of plant material. Two staff members traveled to Newfoundland to provide information on plant material used as evidence in murder trials.

A total of 4110 collections and cultures of fungi were identified during 1984. Principal users of the service were Agriculture Canada (43%), the general public (27%), and Canadian universities (15%). Assistance was provided on the identification of plant pathogens, mycotoxic fungi, fungi used as biological control agents, mycorrhizal fungi, and poisonous and edible fungi. Staff members again provided assistance to the Agriculture Canada research station in Beaverlodge, Alta., in the screening of leafcutting bee cocoons for the presence of chalkbrood. Research stations also received assistance with fungi relating to diseases of crops, storage problems of vegetables and grain, disease resistance screening in potato breeding, boxcar surveys of cereal grains, forest insect and disease surveys, and phytosanitary regulations for the export of seed. The majority of inquiries from the public were for the identification of edible mushrooms and from hospitals for mushrooms suspected of poisonings.

RESEARCH AND TECHNOLOGY TRANSFER

Insects, mites, and spiders

Hemiptera. Research emphasis in Hemiptera was on the systematics, biogeography, and distribution of leafhoppers, plant bugs, and aphids in Canada. In faunistic surveys of Cape Breton Highlands National Park and Newfoundland 140 and 95 species, respectively, were found, including 12 new species and two recently introduced from Europe. A biogeographic analysis indicates that the two islands represent ecological relicts of glacial environments. Published were morphometric and biogeographic analyses of three genera of leafhoppers, establishing eight new species and validating nine synonymized species. A major handbook on the leafhoppers in Canada and Alaska, in preparation, will include 236 species in 36 genera and taxonomic keys to the pests of ornamental and fruit trees. Research on aphids concentrates on the genus *Cinara*. A completed analysis of character variation in a complex of 10 species provided conclusive data on geographic variation, facilitating their identification. Over 25 of the approximately 40 species attacking pine have been characterized and their host-plant ranges and distributions plotted. In preparation is a definitive handbook of the 180 genera of aphids in Canada, one on the plant bugs of eastern Canada, and one on the plant bugs of British Columbia and the Yukon.

Diptera. Larvae of an undescribed species of Chironomidae (chironomid midges) were discovered feeding heavily on the submersed apical buds of the introduced Eurasian water milfoil, *Myriophyllum spicatum*, in interior British Columbia. The milfoil is a major aquatic weed in this continent. Larval and pupal stages of the midge were associated through individual and mass rearing, and a description and scientific name (*Cricotopus myriophylli*) were published. In a second chironomid midge investigation, a problem involving the classification of *Cardiocladius albiplumus* was brought to light by association of the juvenile stages with the adult. Whereas males possess the classical characters of the genus *Cardiocladius*, both larvae and pupae have many characters formerly used to characterize the genus *Eukiefferiella*. Limits of the two genera are evidently in need of further study.

About 2000 typescript pages and 1800 line drawings were finalized for Volume 2 of the *Manual of Nearctic Diptera*. Scientific and technical editing was completed for 65 of the 68 chapters. This book is the companion volume to Volume 1, published in 1981, which covered the introductory chapters and the first 43 families of the order. Volume 2, dealing with the remaining 65 families, as well as the phylogenetic analysis of all Diptera, will be submitted to the printers in 1985 and is expected to appear in 1986. Two handbooks are near completion. The *Horseflies and Deerflies of Canada* (Diptera, Tabanidae) provides descriptions, distributions, illustrations, and aids to the identification of 151 species. The second handbook, on predacious flower flies (Diptera, Syrphidae), treats 163 species in Canada, Alaska, and Greenland. A revision was completed for the New World species of *Paragus* (Syrphidae) with seven Nearctic species, six of which are new, and one Holarctic species. Five species in *Dasyhelea* (Ceratopogonidae) were revised, of which two are new. A major revision of the tribe Blondeliniini (Tachinidae) of North and Central America was completed. This included keys, illustrations, diagnoses, and synonyms for 55 genera and a taxonomic catalog of all species. In addition three new species in separate genera were described. A revision of the *Atylotus* (Tabanidae) of eastern North America was submitted, in which 10 species are recognized. Three of these are new and one is known previously

from the Palaearctic region. Descriptions and keys for adults and some larvae are given. A technical bulletin was completed on the biting flies attacking man and livestock in Canada. This provides general information and a summary of each family, making it extremely useful to anyone in Canada who enjoys the outdoors or is interested in controlling biting flies.

Coleoptera. Numerous papers dealing with the taxonomy and phylogeny of several families of beetles were published or accepted for publication. In Carabidae two papers dealt with adults, one with those of the subgenus *Steropus* of the genus *Pterostichus*, and another with the genus *Abaris*; two dealt with the larval stages, one with those of the genus *Omophron* and the other with *Promecognathus*; and one proposed a notation of the primary setae and pores on larvae of the family. In Staphylinidae 10 papers were prepared, dealing with the genera *Arpedium*, *Eucnecosum*, *Orochares*, *Porrhodites*, *Deinopteroloma*, *Camioleum*, *Thinobius*, *Nepalopeplus*, *Gabrius*, and *Aleochara* and the tribes Megarthropsini and Atanygnathini. In Hydrophilidae a large revision of the Nearctic species of the subfamily Helophorinae, a paper on the genus *Pelosoma*, and one on the taxonomy and faunistics of the subfamily Sphaeridiinae were published. In Chrysomelidae one paper on the larvae of the genus *Pachybrachis* and one revising the North American species of the genus *Ophraella* was published. In Alleculidae one paper was published describing the new genus *Onychomira* and giving a new key to the genera of the comb-clawed beetles of North America. In Scolytidae two papers were published dealing with the genus *Pityophthorus* and one on the taxonomy and faunistics of miscellaneous Scolytidae.

The bibliography portion of the catalog of the Scolytidae and Platypodidae of the world was almost finished (over 7000 references from 1963 to 1983) and the taxonomic portion of the project includes now already 7000 species sheets. A large manuscript (over 700 pages) describing the biology of beetle pests in Canada and the economic damage caused by them (exclusive of the forest industry), a handbook on the hister beetles of Canada, and another handbook (first volume of three proposed) on the weevils of Canada were completed and are being reviewed. Two new introductions in North America, one in Carabidae (*Trechus quadristriatus*) and one in Staphylinidae (*Anotylus insecatus*), were published. Several sections on beetles for the report on the Cape Breton Highlands National Park survey were written. Many important distributional range extensions of beetle species were noted during this survey. A section on the superfamily Staphylinoidea for a book dealing with the insect fauna of southern Africa was accepted for publication. Substantial progress was made on the identification guide to the stored-products and household beetle pests in Canada. A major project reviewing the beetles of the Arctic North America is continuing on schedule.

Lepidoptera and Trichoptera. A paper on the study of the North American *Dioryctria ponderosae* group (Pyralidae) in which three new species were described and a paper on the larva of *Microcrambus elegans* (Clemens) (Pyralidae) were completed and submitted for publication in 1984. A key separating five closely related species of budworm (Tortricidae) in Canada is in press and is expected to be published in January 1985, in which for the first time the eastern species *Choristoneura fumiferana* (Clemens) and *C. pinus* Freeman are morphologically distinguished from their western allies *C. occidentalis* Freeman, *C. orae* Freeman, and *C. biennis* Freeman. A paper revising the tiger moth genus *Dodia* Dyar (Arctiidae) was published, in which a new species was described from northern Canada and Siberia. Draft manuscripts revising several other Arctic cutworm genera were completed. *Epinotia abbreviana* (Fabricius) (Tortricidae), a widespread European pest of *Ulmus* spp., is being reported as the first North American record; specimens of this species were collected and reared by the Newfoundland Forest Research Centre, St. John's. To assist a research project on pests of sunflower in Saskatchewan, *Cochylis arthuri* Dang (Cochylidae) was described from specimens collected and reared by the Saskatoon Agriculture Research Station. A number of undescribed *Epinotia* species (Tortricidae) sent in from Saskatchewan and British Columbia were retained at the Biosystematics Research Institute for future study. Revisional studies of Pseudostenophylacinae and two genera, *Setodes* and *Leptocerus* (Trichoptera), are well under way and will be completed some time in 1985.

Hymenoptera. A paper revised the world species of *Psix*. Eighteen species were recognized, of which 12 are new to science. Phylogenetic relationships within the genus were hypothesized and a key to separate the species was presented. This work is of interest to biocontrol researchers because members of the genus *Psix* attack several insect pest species, such as the green stinkbug. In separate papers two new Nearctic genera were erected. A sawfly genus *Pilacus* was erected to include four species formerly placed in the genera *Macrophya* and *Zaschizonyx*. *Zacremnops* was erected to include two species of Braconidae for-

merly included in the genus *Megagathis*. A handbook on parasitic wasps of the superfamily Chalcidoidea was published dealing with 16 families and 50 subfamilies of this complex taxon. The book is meant to assist students, technicians, and applied and basic research scientists in identifying chalcidoid wasps, especially those wasps important to biocontrol programs. Identification keys are presented in both French and English and much supplementary information such as biology, hosts, and references are included. A paper elucidated the host–parasite relationships of insects associated with *Lonicera* (honeysuckle). Six species of parasitic Hymenoptera, two of these new to science, were recorded. All six were associated with one of four hosts that feed on *Lonicera*. Close cooperation continued with the Agriculture Canada research station in Saskatoon, where a cooperative project on the Hymenoptera associated with sunflower (*Helianthus*) is under way. The professional staff of the Hymenoptera Section are collectively preparing a key to the parasitic Hymenoptera associated with *Helianthus*. The biology, geographic distribution, and host relationships of these parasitoids will be treated in a publication scheduled for 1985. Another publication, which involves all professional members of the Hymenoptera Section, is a handbook for the identification of the families of Hymenoptera. This is designed to be used by the nonspecialist. It will have keys in both French and English and will be extensively illustrated. This paper will be completed in time for our first workshop on the identification of Hymenoptera, which is scheduled for August 1985.

Spiders. A comparison was made of the North American wolf spider *Pardosa fuscula* and its counterpart *P. atrata* of Europe and Asia to determine whether a single Holarctic species or two valid, but allopatric, species exist. Traditionally they have been treated as two species. Museum specimens from Canada, Alaska, Scandinavia, and Siberia showed no consistent anatomical differences, whereas male courtship patterns and blood isozymes from living specimens collected in Ontario and Sweden showed considerable differences. The problem was not solved, inasmuch as the behavioral and biochemical characters probably possess variability that could not be demonstrated in the limited supply of living spiders available. Additional evidence from populations in Siberia and Alaska are needed. At present it seems practical to treat the forms as a single Holarctic species, *P. atrata*. Another study involved the North American cobweb spider, *Steatoda borealis*, and its European relative *S. bipunctata*. The latter has invaded eastern Canada during the past century. Both species occupy identical habitats (crevices of buildings, bark, or stone), and the immigrant is slowly displacing the native one. In the Ottawa area, the urban core is occupied only by *S. bipunctata*, both indoors and out, but limestone cliffs at the periphery harbor either pure *S. borealis* populations or mixed populations. Among farm buildings southwest of the city, one-third contain only *S. bipunctata* and the remainder pure *S. borealis* populations or mixed ones. The mechanism by which displacement takes place was not discovered, but laboratory tests indicate that it does not involve aggression between adults nor differences in niche, prey, life history, or relative rate of reproduction.

Mites. A taxonomic analysis of the oribatid mite genus *Epidamaeus* in the subarctic part of western North America and eastern Siberia revealed the presence of nine species, six of which were described as new to science. Each of the new species was found to be restricted to one continent or the other, in contrast to the Arctic species of the genus, which are mainly Beringian. Also completed was an analysis of Arctic genera of the oribatid family Ceratozetidae in western North America. One new genus and two new species (total 10) were described, as were the immature stages of six of the species for the first time. Seven species are circumpolar. The importance of oribatid mites lies in their role in litter decomposition, humus formation, and mineral cycling; they also have potential as bioindicators and bioinoculants. A critical historical review of the world suprageneric taxa of tarsonemid mites and some of their relatives was submitted for publication. Twelve years in preparation, this work uses the fundamental setal notation of Grandjean to develop new homologies and to propose a revised hierarchy of categories based on the phylogenetic method of Hennig. Three subfamilies (one new), seven tribes (four new), 30 genera (seven new), and six subgenera (one new) are recognized and diagnosed. Eight generic names are placed in synonymy. Representatives of all of the tarsonemid genera previously proposed, including in nearly all cases their type-species, are diagnosed and illustrated, and a new key based on characters from adult males, adult females, and where known, larvae, is presented. Families believed to be related to the Tarsonemidae are also examined. Additional papers were completed, including one on important new synonymy in the genus *Metatarsonemus*, and one containing data supporting a decision regarding

the correct authorship of several family names in the Tarsonemoidea. A comprehensive study of the parasitic associations of larval water mites with their insect hosts was undertaken, including a critical review of all pertinent literature. All previously published records were assessed in light of new information on the taxonomy and biology of water mites and their hosts, and a number of these records were found to be based upon misidentifications or improperly documented associations. Verified records, along with many new observations, were compiled and analyzed to yield new insights into the phylogeny and ecology of water mites. Systematic review of the water mite taxa Arrenuroidea and Aturidae in North America were continued, leading to comprehensive planned publications that will include diagnostic information, keys, and distributional data for all species in these groups. A large paper on the systematics of the erophyoid mite genus *Trisetacus* was published, and research on the related genus *Nalepella* is in progress.

Nematodes. Cooperative work continued on stunt and virus-transmitting nematodes with researchers at the Vineland Research Station, and on insect nematodes with a scientist at Saint-Jean-sur-Richelieu. Statistical analysis of morphometric data confirmed the presence of an undescribed stunt nematode in a complex, which resolves population disparities observed in host preference and behavior. Most significant of the findings of the cooperative work on entomogenous nematodes were two new records of insect hosts of economic importance. In the laboratory, the carrot weevil and a noctuid cutworm suffered up to 100% mortality when exposed to the parasite. The nematode was identified as *Neoplectana carpocapsae* and all life stages were characterized. Other cooperative work was initiated with Plant Health personnel in Ottawa in a survey for the pine wood nematode in Canada. Six new species of plant and terrestrial nematodes were described and a morphological analysis was published of an entomogenous species of importance in biocontrol. Research on root-lesion nematodes, *Paurodontella* and *Rhabditis*, established new diagnostic features which will have significant application in taxonomy, phylogeny, and functional morphology. Fine morphological details of the head of a root-lesion nematode resolved its identity as an undescribed species and provided supplemental characters of value in identifying and classifying these species. A catalog of 4990 primary and secondary types of 396 species housed in the Canadian National Collection of Nematodes was prepared. The Canadian National Collection houses one of the largest nematode type collections in the world.

Vascular plants

A bibliography of information on vascular plants in the Maritime Provinces was completed. Taxonomic studies of rangeland sedges proceeded with the completion of two papers, one concerning the significance of sterile shoots and the other with closely related North American and European taxa in the *Carex disticha* group. In cooperation with the National Museum, sections on aquatic plants were prepared for the *Atlas of the Rare Vascular Plants of Ontario*. The botanical survey and analysis of Cataraqui Marsh, originally undertaken in cooperation with Parks Canada and other agencies, was revised for a technical bulletin. Keys to the aquatic plants of Canada were completed for the first manual of Canadian aquatics. This work will aid in the identification of weedy species of irrigation canals, reservoirs, and recreational lakes. Papers concerning orchid hybrids, breedings systems of Canadian orchids, and taxonomy of the complex genus *Spiranthes* were completed. Work is also being carried out on several species of orache, including *Atriplex prostrata*, *A. patula*, *A. subspicata*, and *A. rosea*, which are weedy in disturbed habitats throughout Canada. Articles are completed on three closely related annual nightshades, *Solanum ptycanthum*, *S. nigrum*, and *S. sarachoides*, and on Russian thistle, *Salsola pestifer*. Final revision of a monograph on the genus *Vaccinium* (cranberries, blueberries), produced on contract with Acadia University, was completed, and the manuscript forwarded to the Scientific Editing Section of Research Program Service for preparation as a Research Branch monograph. Taxonomic clarification of the alfalfa genus *Medicago* continued towards the goal of producing a monograph. During 1984, nine papers were published, two accepted for publication in 1985, and several manuscripts submitted. Two species were added to the genus *Medicago*, namely *M. hypogaea* E. Small and *M. lesinsii* E. Small. A paper was prepared describing evidence that indicates that still additional species should be added to *Medicago*. A simplified taxonomic system was prepared for the different kinds of *M. sativa*, which comprises the cultivated alfalfa and the most important wild variants that can be used for its genetic improvement. A paper was accepted that demonstrated that the glandular hairs that serve to identify certain of these wild variants are potentially of agricultural value as a repellent

against certain beetles. In the course of identification of *Avena* germ plasm collected recently by Agriculture Canada in Morocco, two new species were discovered and described morphologically and cytologically in two papers that were written. The registry of barley cultivars containing about 8000 cultivar names, synonyms, pedigrees, and other relevant data was submitted for publication. This will serve for some time as a basic reference to barley breeding and registration. Within the course of a worldwide taxonomic revision of the barley genus *Hordeum*, it was found that the diploid and tetraploid cytotypes of *H. bulbosum* can be distinguished morphologically. On this basis the two are now regarded as subspecies. In connection with investigations of Section Hordeastrum of *Hordeum* a new method of coding quantitative characters for cladistic analysis has been devised. A paper was published reviewing the biology of a new-problem weed species in Canada—jimsonweed. A paper was accepted for publication reviewing the biology of a newly introduced weed of winter cereals in Ontario—silky bent grass. Electrophoretic techniques were used to test the validity of two conflicting taxonomic treatments for the annual North American members of the genus *Zizania* (wild rice). Ten enzyme systems were examined and 31 populations of wild-rice were collected from sites throughout its range in North America. Allozyme data support Dore's (1969) recognition of two species, *Z. aquatica* and *Z. palustris*. Variation studies in populations of velvetleaf from the northeastern part of North America provided evidence for considerable levels of population differentiation in morphological and physiological traits. Clines in seed weight and seed dormancy were correlated with length of the growing season. In contrast no or low levels of allozyme variability were evident among the 39 populations examined. Genecological studies of five populations of jimsonweed collected from Ohio, Michigan, and southern Ontario provided evidence for significant levels of variation among populations and between and within families for all five populations. Seed weight and cotyledon length increased and days to anthesis decreased with length of the growing season. Levels of morphological, phenological, and allozymic variation were compared in nine newly introduced Canadian and six European populations of the weed species silky bent grass. Considerable differences were evident both between and within Canadian populations of the weed, suggesting that two or even more introductions were involved in the colonization of this weed in Canada. Cytological studies of Section *Absinthium* of *Artemisia* continued. Manuscripts on absinth (*Artemisa absinthium* L.) and St. John's-wort (*Hypericum perforatum* L.) were accepted for publication in the *Biology of Canadian Weeds* series. A numerical taxonomic analysis was carried out on leafy spurge (*Euphorbia esula* complex). The latex chemistry of some of the leafy spurge biotypes is being examined. A manuscript, *Inventory of Canadian Weeds*, has been prepared and completed covering about 700 weeds of agricultural importance. The publication includes English and French common names, distribution, and an annotated bibliography showing distributional data, nomenclatural comments, and the location of pertinent biological data for agricultural researchers. A weed survey of the Peace River District in Alberta and British Columbia was initiated. This work should be completed in 1985–1986. Field work in relation to the flora of the Yukon Territory centered in the unglaciated Ogilvie and Wernecke mountains. This flora project is scheduled for completion in 1987.

Fungi

The North American Matsutake mushroom was correctly named *Tricholoma magniverlare* (Peck) Redhead. This prized edible mushroom, exported fresh to Japan from British Columbia, was shown to occur also in northern Canadian locations with new hosts outside of the ranges of reported mycorrhizal hosts. A second large edible species, causal agent of a rot of living hardwoods, was determined to be correctly named *Hypsizygus ulmarius* (Bull.) Redhead. Investigations of the mushroom flora along the Pacific coast have revealed a significant number of new taxa. *Panellus longinquus* subsp. *pacificus* Libonati-Barnes & Redhead, a newly discovered northern counterpart to a southern hemisphere taxon, decays red alder wood but is also frequently isolated from hemlock stumps experimentally treated by west coast researchers to control the root pathogen *Helerobasidion annosum* (Fr.) Bref. It is a potential control agent. The new species, *Melanotus textilis* Redhead & Kroeger, decomposes fabrics left outdoors along the west coast. Investigation of specimens and literature reports resulted in 15 new namings and considerable synonymy of North American mushrooms. Additionally, mushrooms in the genera *Coprinus*, *Hypholoma*, *Mycena*, and *Stropharia*, known from Europe, were reported from British Columbia or Ontario. Two new genera of wood-rotting fungi (*Mollicarpus* Ginns and *Griseoporia* Ginns) were proposed, one new species (*Hericium americanum* Ginns) was described, and a number of species concepts were clarified through the use of genetic compatibility studies and the critical evaluation of microfeatures.

Taxonomy of the Cereal Rusts was published in a multi-authored treatise entitled *The Cereal Rusts*. This definitive contribution points out the danger of the unduly broad species concepts employed by some cereal workers. Two long-cycled rusts on Berberidaceae were described along with four rusts on Gentianaceae. *Uredo beringianum* (Tranz.) Parmelee on Gentianaceae, a species previously not known in North America, was reported from the Yukon, British Columbia, and Alaska. *Bertia moriformis*, a common wood-degrading ascomycete, was shown for the first time to have two distinct varieties in North America. Descriptions of a new species of *Pyxidiophora* and of *Thuemenella cubispora* (Ell. & Holw.) Boedijn, both members of the Hypocreales, were prepared. Monographs on Canadian and extralimital species of *Leptosphaeria*, *Nodulosphaeria*, and *Entodesmium* (Pleosporales) have been completed. Fourteen new species of *Leptosphaeria* and a new *Nodulosphaeria* were described. Unique and previously unreported appendages were found on the ascospores of most of the species of *Entodesmium* parasitizing legumes. The *Entodesmium* appendage has proven to be a significant taxonomic character and is hypothesized to relate to transmission and infection. A new species of *Lasiosphaeria* was described from decomposing wood. The fruit tree and grape root pathogen, *Roesleria subterranea* (Wienm.) Redhead, was renamed, recorded from British Columbia, and distinguished from a new genus, *Roeslerina* Redhead, which was based on two new species suspected of parasitizing roots of western conifers. *Meliolina subramanianii* Hughes & Pirozynski was described for the first time and six species of the foliicolous ascomycete genus *Schniffnerula* and one species of the anamorphic genus *Sarcinella*, which occur on Compositae in the americas, have been redescribed and illustrated. *Schiffnerula barnadesiae* (Pat.) Petrak and its *Mitteriella* and *Questieriella* synanamorphs and a new genus, *Digitosarcinella* Hughes, have been described. Two new species were described in a revision of *Trichoderma* section *Longibrachiatum*. These fungi produce cellulase enzymes with potential for commercial application in the production of alcohol for transportation fuels. The life cycle of *Polymyxa graminis* Ledingham, a fungal vector of several destructive cereal viruses, has been elucidated from studies of infected host root cells in the transmission electron microscope. *Lagena radicicola* Vanterpool & Ledingham is a widely distributed root parasitic organism in Canada but has received very little attention. Ultrastructural studies of its zoospores have shown that it is more closely related to the colorless flagellates than to the true Oomycetes where it has been traditionally classified. A comprehensive classification of the genera and species of the Spizellomycetales, an order of zoosporic fungi, was published in 1984. The *Compendium of Plant Disease and Decay Fungi in Canada*, an up-to-date reference book for plant pathologists, plant breeders, ecologists, and mycologists, will be published as an agriculture handbook. This volume contains about 30 000 entries and treats nearly 8000 names of disease- and decay-causing fungi in Canada. A manuscript on the parasitic fungi previously collected on vascular plants in the Yukon was prepared and to this manuscript will be added collection results made in 1984. About 175 parasitic fungus species will be reported on the native and weedy plants of this region of Canada. Documentation of the use of an illicit hallucinogenic mushroom disguised in food was provided for law enforcement agencies. A cooperative study with scientists of the U.S. Department of Agriculture has identified the causal agent of a new disease of maize in Latin America as a new species of *Marasmiellus*. Assistance has also been given to researchers in the Federal Republic of Germany and Quebec in their search for antibiotics in unusual basidiomycetes. Puzzling biochemical analyses were resolved by correcting the identifications of cultures used in one case. The ascomycete genus *Mycosphaerella* is a huge genus of over 2000 published names containing many plant pathogenic fungi. An index is being prepared which will include an alphabetical listing of all the published names, authorities, place of publication, homonyms, and new names created for later homonyms and key literature citations. A major survey for chalkbrood disease (*Ascosphaera* spp.) affecting the alfalfa leafcutter bee in western Canada was completed. Classic chalkbrood was found, for the first time in Canada, in nine samples of leafcutter bee cocoons. Five other species of *Ascosphaera* in addition to *A. aggregata* Skou were observed from these materials, including three new species that have not been previously described. One of the new species may be pathogenic, causing an early instar larval mortality in the leafcutter bee. The other two species are saprophytic and may cause spoilage of larval food stores. Work on mycotoxin production by *Fusarium* species, conducted in collaboration with other Agriculture Canada researchers, and with university and government researchers outside Agriculture Canada, has been concerned with factors affecting mycotoxin production in the field and in cultures grown in the laboratory. Field studies were concerned with deoxynivalenol (vomitoxin) production by *Fusarium*

graminearum Schwabe. In the laboratory the toxigenic potential of isolates of *F. crookwellense* Burgess et al., *F. equiseti* (Corda) Sacc., *F. graminearum* Schwabe, *F. semitectum* Berk. & Rav., *F. sporotrichioides* Sherb., and various isolates that belong in the section *Liseola* Wollenw. et al., was investigated. Data obtained from some of these studies helped to shed some light on conflicting hypotheses concerning the origin of trichothecenes found in "yellow rain" samples from southeast Asia. Successful axenic culture of blueberry seedlings and subsequent root inoculation of three common soil fungi from the genus *Oidiodendron* confirmed the ability of these fungi to form a mycorrhizal association with blueberries. This root-fungus association enables these ericaceous plants to more effectively take up phosphates, nitrogen, and other mineral nutrients from the soil. Assistance is being provided to a project of Health and Welfare Canada, Health Protection Branch, to establish reference standards of allergenic potency for selected highly allergenic fungi. Mycological expertise is being provided to ensure proper storage, handling, and purity of the fungal isolates. Health and Welfare personnel are being trained in the proper cultural and mycological procedures. The Health and Welfare project is part of a larger World Health Organization project to establish reference standards for all types of allergenic substances. The autofluorescence under ultraviolet light of vesicular–arbuscular mycorrhizal fungi was observed and its possible taxonomic significance was investigated. An invitational paper, *Communication Problems in Interdisciplinary Research*, was published. This paper addresses problems ranging from communication between collaborators of different disciplines to finding a publication vehicle that will be seen by all those persons who need the findings of an interdisciplinary study. Thirty Canadian species were fully illustrated and described for *Fungi Canadenses*. These include a monograph of 11 species of *Puccinia* (rust fungi) parasitic on Ranunculaceae; *Phyllosticta ampelicida* (Engelmann) van der Ada, causal agent of black rot of cultivated grapes, *P. celastrina* (Died.) van der Aa, causal agent of a new disease of container growth *Euonymus fortunei* 'emerald gold', and eight other parasitic *Phyllosticta* species; two Endogonaceae, one saprophytic and one endomycorrhizal; four fungicolous or lignicolous species; and *Cephaliophora tropica* Thaxter, a hyphomycete found to be associated with reptile eggs in captivity.

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Research

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Chemistry and Biology Research Institute, Ottawa, Ontario

PROFESSIONAL STAFF

A.I. de la Roche, BSc, MS, PhD	Director
C. McCarthy	Administrative Officer

Symbiotic Nitrogen Fixation

R.W. Miller, BSc, PhD	Program Leader; Rhizobium and legume physiology
E.S.P. Bromfield, BSc, PhD	Rhizobium ecology
F.D.H. MacDowall, FSc, MSc, PhD	Legume physiology
C. Preston, BSc, MSc, PhD	Soil nitrogen
L.R. Barran, BSc, MSc, PhD	Program Leader; Rhizobium genetics
R.M. Behki, BSc, MSc, PhD	Rhizobium genetics
R.J. Watson, BSc, MSc, PhD	Rhizobium genetics

Stress Physiology

M.K. Pomeroy, BSc, MSc, PhD	Program Leader; Winter survival of cereals
C.J. Andrews, BSc, PhD	Winter survival of cereals
Y. Cloutier, BSc, MSc, PhD	Desiccation stress
E.F. Schneider, BS, MSc, PhD	Snow mold damage
J. Singh, BS, PhD	Freezing injury—membranes

Mycotoxins

R. Greenhalgh, BSc, PhD	Program Leader; Analytical and natural products chemistry
B.A. Blackwell,[1] BSc, MSc, PhD	Spectroscopy
J.D. Miller, BSc, MSc, PhD	Fungal physiology
H. Morita, BSc, MSc, PhD	Organic chemistry
J.C. Young, BSc, MSc, PhD	Analytical and natural products chemistry

Plant Pathology

R.C. Sinha, BSc, MSc, PhD, DSc	Program Leader; Virus and mycoplasma vector relationships
L.N. Chiykowski, BSA, MSc, PhD	Leafhopper-transmitted mycoplasma
Y.C. Paliwal, BSA, MSc, PhD	Aphid- and mite-transmitted viruses

Environmental Chemistry

S.U. Khan, BSc, MSc, PhD, CChem, FCIC, FRSC	Program Leader; Herbicides and insecticides
D.S. Gamble, BSc, MSc, PhD, FCIC	Herbicide chemistry
A. Picman, MSc, PhD	Phytochemistry

Soil Chemistry and Mineralogy

M. Schnitzer, BSc(Agr), MSc, PhD, FCSS, FASA, FSSSA	Program Leader; Soil chemistry and organic matter
L.M. Benzing-Purdie, BSc, MSc, PhD	Soil nitrogen
Y.K. Chan, BSc, PhD	Soil microbiology
K.C. Ivarson, BSc, MSc, PhD	Soil microbiology
H. Kodama, BSc, MSc, DSc	Program Leader; Soil mineralogy—crystal chemistry
M. Ihnat, BSc, PhD, FAOAC	Trace element chemistry
N.M. Miles, BSc	Soil mineralogy
G.J. Ross, BSA, MSc, PhD	Soil mineralogy
S.S. Singh, BSc, MSc, PhD	Soil chemistry

Mineral Analyses Services

H. Kodama, BSc, MSc, DSc	Head of Services

Analytical Chemistry Services

M. Ihnat, BSc, PhD, FAOAC	Head of Services

Electron Microscope Centre

I.L. Stevenson, BSA, MSA, PhD	Program Leader
G.H. Haggis, BSc, PhD	Electron microscopy

Honorary Research Associate

D. Siminovitch, BSc, MSc, PhD, FRSC	Frost hardiness

Departure

S.M. Lesley, BSc, MA, PhD Retired	Rhizobium physiology

VISITING SCIENTISTS

Y.K. Arora, BSc, MSc, PhD Haryana Agricultural University, Hissar, India	Mycoplasma biochemistry
G. Catroux Ingénieur-agronome, INRA, France	Soil nitrogen
G. Calderoni Professor in geochemistry, University of Rome	Soil organic matter
M. Spiteller University of Gottingen, West Germany	Soil nitrogen

Visiting Fellows, National Sciences and Engineering Research Council

A. Al-Jobore, PhD	Biochemistry
J.E. Irvin, PhD	Microbiology
A.M. Johnson-Flanagan, PhD	Freezing injury—cell biology
R. Lawuyi, PhD	Mycotoxin chemistry
J.R.J. Paré, PhD	Spectroscopy
R.G.L. Wheatcroft, PhD	Genetic engineering

[1]Appointed 1 April 1984.

INTRODUCTION

The Chemistry and Biology Research Institute (CBRI) conducts research and development in areas of national importance to agriculture. The main thrusts are in biotechnology, preservation of natural resources, environmental protection, and food safety. The multidisciplinary approach in nitrogen fixation seeks to improve the nitrogen-fixing capacity of forage legumes through molecular genetics and conventional technologies. Research on mycotoxins examines the health and socioeconomic factors associated with fungal metabolites in food and feeds through multidisciplinary in-house research and close cooperation with other branch establishments, other government departments, universities, and the private sector. The stress physiology program emphasizes genetic engineering technology and mechanisms of stress injury and resistance combined with field experiments to develop crops resistant to low temperature, drought, and salinity stresses.

Notable achievements in 1984 include the cryopreservation for several years of aster yellows mycoplasma in vector insects; new insights on the nature and distribution of pesticide residues, their potential release, and their bioavailability; the initiation of research into the genetic regulation of pesticide-degrading plasmids via recombinant DNA technology.

The acquisition of new equipment and resources in 1984 enabled the institute to maintain its lead in biotechnology, especially in the area of plant and fungal molecular genetics and the application of recombinant DNA techniques to crop production, crop protection, and nitrogen fixation. The Electron Microscope Centre, the Analytical Chemistry Services, and the Mineral Analyses Services continued to provide services and to improve methodologies in response to the needs of the institute and other departmental establishments.

The interaction with the universities, the private sector, and research establishments outside Canada is a high priority at the institute. During the past year several collaborative projects were initiated with Canadian universities, industries, and European research organizations.

This report summarizes only the highlights of our achievements in 1984. Reprints of research publications and copies of this report are available from the Chemistry and Biology Research Institute, Research Branch, Agriculture Canada, Ottawa, Ont. K1A 0C6.

A.I. de la Roche
Director

SYMBIOTIC NITROGEN FIXATION

Rhizobium ecology

Experiments carried out at two field sites have provided evidence for major ecological limitations on symbiotic nitrogen fixation in alfalfa. A negative correlation was demonstrated between native *Rhizobium* population size and the degree of nodulation by inoculant strains. Single-colony isolates from field-grown nodules were identified by bacteriophage typing. Inoculant strains were not recovered in more than 20% of the nodules and forage yield showed no significant response to inoculation. Significant differences in the distribution of phage groups between field locations were demonstrated but there was no obvious influence of alfalfa genotypes or inoculant strains on these distributions. Although the relative competitive abilities of inoculant strains were consistent under axenic conditions and in soils, considerable heterogeneity was demonstrated among host plants for selective nodulation with different strains. Host preference for certain strains varied considerably within cultivars but differences between the test cultivars were not significant.

Physiology of nitrogen fixation

Characterization of the isolated nitrogenase enzyme system established that lowering the reaction temperature from 25°C to 12°C slowed the reaction severalfold and severely limited the reduction of dinitrogen to ammonia. The proportion of reducing equivalents used in hydrogen production increased relative to the reduction of other substrates, leading to a reduction in the energy efficiency of the system at low temperatures. Under the same conditions intact nodules, in contrast, showed a decline in overall activity of less than twofold and a significant increase in energy efficiency (less hydrogen produced). Moreover, luminometric measurements of adenine nucleotides in intact nodules and bacteroids indicated that, based on results with the isolated enzyme, ATP concentration *in vivo* was not adequate for saturation of the enzyme system to give optimal reaction rates. This seemingly anomalous behavior of the nitrogenase system *in*

vivo requires further investigation to determine how symbiotic nitrogen-fixing systems compensate for the effects of environmental stress and maintain nitrogenase activity and energy efficiency at a high level of comparison to the isolated enzyme system.

Host physiology and recognition

The effects of long-term acclimation of alfalfa at low temperature on the nodular nitrogenase system were determined. Enzyme activity remained higher than expected but initially high-energy efficiency declined with acclimation, pointing to the need for more physiological information on the basis of these phenomena.

Soybean lectin carbohydrate-binding studies demonstrated that the putative initial step in host *Rhizobium* recognition leading to nodulation is more complex than expected. Binding determinations using nuclear magnetic resonance spectroscopy showed that there were up to eight carbohydrate binding sites per lectin tetramer. New chemical synthesis of sugar ligands facilitated this work, which is aimed at elucidating recognition phenomena at the molecular level.

Soil nitrogen cycle

The construction of a new emission spectrometer and the application of isotope dilution techniques have provided estimates of the contribution of soil nitrogen and symbiotically fixed nitrogen to the production of biomass in forage legumes. In addition, the transfer of symbiotic nitrogen between crop plants and the fate of nitrogen fertilizer added to soils will be determined with these techniques.

Molecular genetics

Total DNA purified from each of 300 Tn5-mutants of *Rhizobium meliloti* has been analyzed by radioactive probing. These analyses have demonstrated the presence of bonafide Tn5 insertions in 95% of the mutants. None contain inserts in the known *nif* gene segments, but inserts have been identified within the known *nod* gene region.

Cloned replication regions of *R. meliloti* plasmids have been subcloned and their stability has been tested during extended growth, and by passage through nodules. The *rep* regions have been finely localized to DNA segments less than 3.0 kilobase pairs in size and none is completely stable in *Rhizobium*, indicating that genes conferring stability must exist elsewhere in the original plasmids. The *hic* (high colicin release) region of Co1E3-CA38 has been characterized. The elements of the *col-imm-hic* operon required for the high production of the *col* and *imm* gene products have now been identified, revealing a novel mechanism for selective transcription of that operon. Cloning vehicles utilizing that mechanism for high production of any gene product have been constructed, but final testing of their efficiency is required.

Preliminary results indicate that the introduction of the rifampicin marker into *R. meliloti* IZ450 significantly diminished competitive ability. Loss of the 150 Md plasmid resulted in a further reduction of competitive ability but it was less than that caused by the introduction of the rifampicin marker.

STRESS PHYSIOLOGY

Biotechnology

Freezing tolerance was induced in suspension cell cultures of alfalfa and winter rape, and the hormonal and temperature requirements for this process were defined. Abscisic acid was able to replace low temperature as a requirement for cold acclimation of winter rape, but not for that of alfalfa cultures. Removal of benzyl adenine from the culture medium was required to attain maximum hardiness.

Differential interference contrast microscopy coupled to video recordings was used to study membrane deletion in isolated, single rye cells and in cultured cells of winter rape during hyperosmotic stress. Membrane segments were released as vesicles from the plasmalemma into the cytoplasm and between the cytoplasm and the cell wall. In stress-tolerant cells, the membrane material was reincorporated when the cells were deplasmolyzed.

The presence of calcium increased survival of enzymatically isolated winter wheat cells during ice encasement at -1°C and freezing at lower temperatures. Uptake of ^{86}Rb by isolated cells following ice encasement or severe freezing stress was enhanced by calcium. Cell injury increased progressively when the icing temperature was reduced from -1 to -2 and -3°C, but the presence of calcium in the suspending medium reduced damage.

Freezing and desiccation stress

The levels of freezing tolerance induced by desiccation of winter cereal seedlings were similar to those induced by cold acclimation in wheat and rye, but considerably less in barley and oats. This was associated with a more rapid desiccation injury in barley and oats, precluding the completion of the hardening process. Proteins from various subcellular fractions of wheat and rye have been analyzed by two-dimensional electro-

phoresis. During cold acclimation and desiccation, protein changes occurred, primarily in chloroplasts and the soluble-protein fraction. Winter cereals survived ice encasement better and plants accumulated less ethanol but more CO_2 under light than dark conditions. Plants utilized their carbohydrate reserves more slowly in light than dark and generated photosynthetic oxygen. This created a partial aerobic environment in the ice which was conducive to increased survival.

Field trials and screening

Field survival of winter wheat was generally good during 1983–1984, except in localized areas where water accumulated and icing occurred. Two seedings in September gave the highest cold hardiness and survival rate, but the latest seeding on 20 October 1983 gave the highest survival rate under ice encasement. The cultivar Houser continued to exhibit high levels of freezing resistance and ice tolerance. Eighty winter wheat and triticale cultivars and lines, including the Canadian Winter Hardiness Nursery and the Ontario Winter Wheat Coop, were screened for winter survival and ice tolerance. In the field, almost total kill occurred in the iced plot, whereas good differential survival among cultivars and lines was obtained under controlled environments. Laboratory experiments showed that reducing the cold-hardening temperature from 2°C day and 0°C night to 0°C day and −5°C night significantly enhanced cold hardiness and ice tolerance of a series of winter cereal cultivars.

Diseases

Breeding lines and foreign introductions of winter cereals were screened for resistance to snow mold diseases, but none of the plant materials tested was more resistant than the cultivars currently in commercial production. *Typhulas* and *Gerlachia* were the most common pathogens inciting snow mold diseases in commercial planting in eastern and central Ontario. *T. phacorrhiza* was observed on more farms this past year than in the previous two years, while sclerotia of a *Typhula* similar to *T. ishikariensis* var. *canadensis* was isolated for the first time from winter wheat in Ontario. None of the fungicides used in a screening program gave satisfactory control of snow molds. In the laboratory, *Typhulas* were observed to incite diseases by the direct development of hyphae from the sclerotia while spores appear to play no role in dispersal or infection.

Cold hardiness of winter wheat and barley declined significantly when infected with barley yellow dwarf virus, and decreased further when plants were flooded at low temperature. Virus infection reduced carbohydrate levels and increased glycolytic metabolism during ice encasement.

MYCOTOXINS

Deoxynivalenol

The large-scale fermentation process for making 3-acetyl deoxynivalenol (ADON) has been modified utilizing *Fusarium culmorum*. In addition, hydrolysis of ADON was achieved on an ion-exchange resin giving a cleaner product. Two crystalline forms of deoxynivalenol (DON) have been obtained. Over 150 g DON and 500 mg ^{14}C-labeled DON (0.8 μm Ci/mg) have been produced for toxicological and feeding studies.

DON can be thermally induced to form an isomer (isoDON), in which the configuration of the A ring has changed. IsoDON was identical to a contaminant found by workers in the United Kingdom in the crust and bread baked from DON-contaminated wheat.

Fungal secondary metabolites

Sixteen minor metabolites have been isolated from crude fungal extracts of *F. roseum* var. *graminearum*. These compounds were characterized by nuclear magnetic resonance (NMR) (^1H, ^{13}C, $^1H/^1H$ correlation and $^1H/^{13}C$ 2D) and mass spectrometry (gas chromatography–electron impact and fast atom bombardment). In addition to the trichothecenes, other mevalonate-derived compounds were characterized, including culmorin, culmorone, and the modified trichothecenes sambucinol and sambucoin. Most of these metabolites are also produced by *F. culmorum*, but in different amounts.

Microbiology

Fermentation studies in stirred jars with *F. culmorum* were undertaken to determine nutritional, physical, and production parameters during trichothecene synthesis. In fermentations yielding ADON (730 mg/L), significant amounts of culmorin, dihydroxy calonectrin, and sambucinol were also produced. Changes in nitrogen and carbohydrate concentrations indicate these two factors are involved in inducing synthesis, but glycerol is not utilized. NADPH-generating ICD necessary for trichothecene synthesis showed an unexpected correlation with the rate of ADON products.

Degradation and decontamination studies with DON

The differential resistance to *F. graminearum* infection and DON formation in 21 wheat, rye, and triticale cultivars was estimated by measure-

ment of DON and ergosterol levels. The ability of wheat cultivars to degrade DON was examined *in vitro*. These studies showed that cell suspension cultures of the resistant cultivar Frontana degraded ^{14}C-DON into at least four labeled products, whereas the susceptible cultivar Casavant did not significantly degrade DON.

Both DON and ADON were degraded in a soil extract media, by isolates from a cornfield soil in the presence and absence of chloramphenicol. Several degradation products were detected but not characterized.

Treatment of contaminated wheat with aqueous sodium bisulfite prior to milling resulted in a 90% reduction of DON levels; on baking the resultant flour, however, some DON was reformed. This work led to a kinetic study of several trichothecenes with sodium bisulfite. Only those trichothecenes with an 8-keto group reacted (e.g. DON and its derivatives); characterization of the reaction products indicates that in addition to adduct formation, some degradation of DON had occurred.

In vitro experiments with rumen fluid indicated that ADON is rapidly deacetylated to DON, which in turn is degraded. The main metabolite isolated revealed that the epoxy moiety in DON had been reduced to a double bond. The same metabolite was found in the urine of sheep dosed with ^{3}H-ADON.

Biosynthetic studies

The incorporation of ^{13}C-labeled (specific and double) acetate by *Fusarium roseum* was completed. A similar study with *F. culmorum* gave incorporation in culmorin, ADON, dihydroxy calonectrin, and sambucinol. Maximum incorporation (8–10% ^{13}C at specific sites) was achieved through multiple additions at critical times during the culture growth cycle. NMR pulse sequences (i.e. polarization transfer techniques) were used to determine incorporation levels, and ^{13}C/^{13}C homonuclear 2D NMR was developed to determine coupling patterns in labeled extracts. The incorporation patterns for single and doubly labeled acetate was consistent with the proposed mevalonate-derived biosynthetic pathway for ADON.

Analysis

Mass spectroscopy (MS) linked-scan experiments were carried out with 10 trichothecene mycotoxins and the parent–daughter ion relationships were established. These data will be used to determine the ^{14}C-labeling pattern in secondary metabolites of *F. culmorum* by their fragmentation pattern. Fast atom bombardment mass spectroscopy has been demonstrated to be an effective method for screening crude fungal extracts for secondary metabolites. A rapid high-performance liquid chromatography procedure for sterigmatocystin was developed and used to analyze single-cell protein from *Chaetomia* spp. The results were confirmed by gas chromatography and mass spectroscopy.

PLANT PATHOLOGY

Peach X-disease

Peach X-mycoplasma (PXM) antigens were detected by enzyme-linked immunosorbent assay (ELISA) in clarified extracts prepared from only 5-g samples of infected leaves of the following host plant species: carrot, red clover, white clover, alsike clover, annual chrysanthemum, *Gilia capitata*, and *Potentilla intermedia*. Several of these plant species, often present in or near peach orchards, could serve as natural reservoirs of the pathogen. Heterologous serological reactions showed that it is possible to use ELISA to differentiate peach X-disease from aster yellows, clover phyllody, and clover yellow edge diseases. Transmission studies on host susceptibility to PXM, using the leafhopper *Paraphlepsius irroratus* as the vector, showed that annual chrysanthemum was the most susceptible species, followed by alsike clover, ladino clover, and red clover. Acquisition access tests showed that aster and red and alsike clovers are poor acquisition hosts, whereas annual chrysanthemum and celery are relatively efficient sources of PXM.

Aster yellows disease

The use of frozen leafhoppers as a vehicle for long-term storage of aster yellows mycoplasma (AYM) was examined. Infectivity of a western isolate of AYM was preserved for a longer time in samples of *Macrosteles fascifrons* stored as whole insects or as clarified insect extracts at −70°C than at −28°C. Infectivity of the AYM isolate was detected after 5 yr but not after 6 yr in whole leafhoppers stored at −70°C. This isolate was also preserved at −70°C in the leafhopper species *Elymana sulphurella*, *Scaphytopius acutus*, and *Athysanus argentarius* for 4 yr, the longest time tested. However, in the species *Aphrodes bicinctus*, infectivity was detected after 6 mo but not after 1 yr. Two other isolates of AYM, both resembling an eastern strain, were infective after 4.5 yr, the longest time tested, when stored in whole *M. fascifrons* at −70°C.

Cereal viruses

A disease causing blotchy mosaic symptoms was observed on wheat plants at two locations in

Ontario. A spherical (28 nm), sap-transmissible virus was determined to be the cause of the disease. The virus was shown to be serologically indistinguishable from cocksfoot mild mosaic virus (CMMV), which is known to occur only in Europe. Mite transmission studies showed that *Aceria tulipae*, which is a vector of wheat streak mosaic virus (WSMV) but not of brome mosaic virus (BMV), was able to transmit BMV at a low efficiency when the mites were fed on wheat plants containing a mixed infection of the two viruses. This demonstrates a low-level "helper" activity of WSMV for BMV transmission, which could play a role in field dissemination of BMV.

Forage legume viruses

The viroid-like (VL) RNA of lucerne transient streak virus (LTSV) was shown to be a satellite of the linear, genomic RNA of the virus. It was shown that the replication of VL RNA of LTSV can be directed by the genome of southern bean mosaic virus (SBMV) but not by the genome of CMMV and that the RNA is encapsulated in the SBMV virions. SBMV virions containing the VL RNA induced a disease of increased severity in plants showing the pathogenicity-modifying property of the RNA. Also, this demonstration of genetic homology between LTSV and SBMV supports designation of LRSV as a sobemovirus.

ENVIRONMENTAL CHEMISTRY

Nonbiological degradation of atrazine

Hydrogen ions and undissociated carboxyl groups in a quantitatively characterized fulvic acid were found to be the only catalytic agents for the hydrolysis of atrazine. No evidence of catalysis by carboxylate ions was observed. A predictive equation was produced for the half-life of atrazine in dissolved organic matter. It was observed that atrazine is hydrogen bonded in a labile equilibrium, to an identifiable set of protonated carboxyl groups, which acts as Bronsted acid catalysts for hydrolysis. KCl at 0.1 *M* changes the degree of protonation of the carboxyl groups, without otherwise affecting the atrazine complexing. Cu (II) chelation both reduces and weakens the complexing through a combination of carboxyl group blocking and fulvic acid aggregation.

Fate of deltamethrin in an organic soil

Deltamethrin labeled with ^{14}C at the methyl or benzylic position showed a steady decrease of extractable ^{14}C residues and a corresponding increase of bound ^{14}C residues over a 180-day incubation period. The degradation of deltamethrin was slower under the anaerobic than aerobic condition. The insecticide was degraded in the organic soil by hydrolysis at the ester linkage followed by the formation of oxidative products. A small portion of bound ^{14}C residues in soil was identified as 3-(2,2-dibromovinyl)-2,2-dimethylcyclopropanecarboxylic acid, whereas the remainder constituted unidentified products.

Bound pesticide residues in bean plants

The amount of bound ^{14}C residues found in bean plant treated with deltamethrin labeled with ^{14}C at the methyl or benzylic position was higher in the benzylic label treated plants. Deltamethrin and a number of metabolites present in the plant as bound ^{14}C residues were released and identified with a high-temperature distillation technique followed by thin-layer and gas-chromatographic analyses. A major portion of the unextractable products remaining was of unknown composition. A small proportion of the bound ^{14}C residues from plant tissues was released after incubation with enzymes. Although these bound residues were present in small amounts and may be neither detected nor determined by routine analysis involving solvent extraction, they can nevertheless be of toxicological concern.

Pesticidal activities of secondary plant metabolites

Studies on autotoxicity of sesquiterpene lactones and phenolic acids present in the aggressive weed *Parthenium hysterophorus* were examined. It was observed that the germination rates of achenes of this weed increased with increasing distance between them, and with an increasing washing period preceeding the germination. The inhibition of germination by water-soluble autotoxins is temporary and its duration is determined by their concentrations. Water solutions of two major sesquiterpene lactones of this plant are autotoxic to its own seedlings and young plants.

The antifungal protective properties of hulls of two oat cultivars and their extracts were investigated using 15 fungal species. Compounds identified in the extracts were phenolic acids present free or in the form of soluble or insoluble esters. It was found that the hulls function as a mechanical barrier and various forms of phenolic acids in hulls act as chemical antifungal agents.

SOIL CHEMISTRY AND MINERALOGY

Soil carbohydrates

Evidence for the formation of melanoidins in soils was obtained. Melanoidins are dark brown N-containing polymers that result from the interaction of carbohydrates with amino acids. The data were obtained in incubation studies in γ-irradiated and autoclaved soils with ^{15}N-labeled amino acids. The reaction products were characterized by solid-state ^{13}C- and ^{15}N-NMR spectroscopy. While the exact chemical structure of melanoidins is still unknown, a possible intermediate has been isolated.

Studies on the effect of temperature on Maillard reaction products showed that an increase in temperature increased the aromaticity of low- and high-molecular-weight products.

Chemistry of humic and fulvic acids

The oxidative degradation of humic acids extracted from Paleosols (buried soils), ranging in radiocarbon ages from 6000 to 30 000 years, showed that humic acids 22 000 years and older produced significantly greater quantities of benzene tetra-, penta-, and hexa-carboxylic acids than did the oxidation of younger humic acids, including those extracted from agricultural soils. These data show that the molecular complexity or stability of the humic acids increased with time.

Effects of fertilizer applications and crop rotations on the chemical composition of humic acids extracted from Orthic Brown Chernozem soils in Saskatchewan were investigated. Humic acids extracted from soils under continuous wheat and fertilized with nitrogen and phosphorus as required were significantly more aromatic than humic acids extracted from soils under continuous wheat that did not receive nitrogen fertilizer. This indicates that the application of sufficient N is necessary for the synthesis of more aromatic, that is, more stable humic acids.

Soil nitrogen

A number of heterocyclic N-compounds were identified for the first time as significant components of the "unknown" soil-N fraction. This information will lead to a more efficient utilization of the soil-N and to a more comprehensive understanding of the soil-N cycle.

Many soil bacteria are capable of fixing N_2 but usually lack adequate supplies of available energy. A new *Pseudomonas* species isolated from soil was demonstrated to use efficiently simple phenolic compounds as carbon and energy sources for N_2 fixation. Since plant-derived monomeric phenols are commonly found in plant-soil systems, these compounds could be an economical energy source for asymbiotic N_2 fixation in many carbon-limited environments. These findings are crucial for elucidating new aspects of nitrogen cycling in soils where rhizosphere microbial activities affect nitrogen uptake by plants.

Soil microbiology

Thiobacillus ferrooxidans (a bacterium isolated from Canadian cold acid sulfate soils) was found to oxidize Fe at 4°C to H_2SO_4 and the yellow mineral jarosite $[KFe_3(SO_4)_2(OH)_6]$. The data showed that the bacterium was responsible for the acidity of these soils and their yellow mottles of jarosite.

At pH 2.0, the yeast-like stages of the dimorphic fungus *Scytalidium acidophilum* fermented glucose to alcohol in 98% yield. This was better than the commercial yeast fermentation where 90% of the theoretical yield is acceptable.

The recently licensed insecticide deltamethrin was found to be degraded by soil microbes, thus preventing its accumulation in soils.

Acid rain and soil acidity

The fertilizer–precipitation acidity ratio (FPAR), which represents the hydrogen ion concentration produced by fertilization over that due to precipitation, may be used to indicate the contribution of acid rain to soil acidity. The FPAR ratio ranges from 1 in most of the Atlantic region to over 100 in some parts of southern Manitoba and in the Okanagan valley area of British Columbia. From the Montreal–Quebec City region to southwestern Ontario region, the ratio varies from 1 to 4. FPAR varies from 8 to 20 in the prairies region of Saskatchewan and Alberta, in the Peace River region, and in the coastal region of southern British Columbia. These ratios indicate that fertilization is the key factor in causing soil acidification.

Treatment of acid soils with gypsum

Further investigation on the equilibration of acid soils with $CaSO_4$ (gypsum) solution resulted in the following reaction sequence: $SO_4^{=}$ which dissociated from $CaSO_4$ reacted with clay surfaces where exchangeable sites had been blocked by Al "hydroxide" or similar compounds to form a neutral aluminum hydroxy sulfate phase. Consequently the exchangeable sites on clay surfaces were restored with the release of excess OH resulting in an increase of pH.

Acidification in the Okanagan Valley

Within 12 yr of orchard management, acidification produced by fertilization and irrigation

in Okanagan apple orchards has lowered soil pH to less than 3.5 and greatly reduced permanent-charge action exchange capacity, base saturation percentage, and ratios of exchangeable Ca/Mg, Ca/K, and Mg/K. Acidification had also produced large amounts of phytotoxic Al and Mn and decreased mineral crystallinity as well. Broadcast application rather than band application near the trees of nitrogen fertilizer and elimination of over-irrigation are reducing the rate of acidification. Liming with the appropriate mixture of calcitic and dolomitic limestones should correct most of the adverse effects of acidification.

Characterization of smectitic minerals in soils

Problems of differentiating soil vermiculites and smectites in the acid and leached Ae horizons of podzolic soils prompted an investigation into the expansion characteristics and layer-charged distribution of these minerals. It was found that these soil smectites expanded like normal ones when intercalated with glycerol but that they contracted like typical vermiculites when saturated with K. It is postulated that the dominant tetrahedral charge and the inherited mica characteristics may play a major role in the behavior of these soil clays.

Removal of amorphous components from soils

B horizons of podzol soils often require treatments for the removal of noncrystalline inorganic soil components prior to the identification and quantification of crystalline mineral components. To that end, chemical extraction with a reagent such as Tiron has been found very effective. As other chemical reagents, however, Tiron also dissolves, to some extent, crystalline mineral components. Gibbsite, for example, present in some eastern Canadian soils may be dissolved by the reagent up to about 25% depending upon particle size of the mineral. A simple method was devised to estimate the original quantity of the mineral. It requires only a measurement of the amount of Al extracted at two different temperatures.

MINERAL ANALYSES SERVICES

Mineral Analyses Services provided more than 2000 X-ray diffractograms and approximately 300 infrared spectra to 35 professional and technical staff from branch establishments, other government departments, and universities. The services also contributed significantly to more than 25 research publications, reports, and presentations to conferences, which dealt with mineral characterization of Canadian soils, mineral weathering, mineralogy of Alberta tar sands, soil acidification, acid sulfate soils, mineral equilibrium in soil systems, the nature of soil clay minerals, and methodology development for mineral characterization and quantification.

The capacity of the Mineral Analyses Services laboratory was increased by designing a new device and modifying a number of techniques for the preparation and pretreatment of samples. A special heating step was designed to acquire diffraction data of a specimen being heated at temperatures up to 200°C on the sample holder of a Philips X-ray diffractometer. This device eliminates rehydration of specimens that are highly hydroscopic and allows accurate temperature readings of the specimen on the holder.

ANALYTICAL CHEMISTRY SERVICES

Analytical Chemistry Services provided branch establishments with chemical analyses in support of research projects in areas of soil management and protection; land use; energy production and conservation; environmental quality and production and improvement of dairy cattle and poultry; production improvement of cereals, oilseeds, forages, and horticultural and field crops; food processing and new product development; and food safety. A wide range of agricultural research materials was analyzed for constituents such as dietary fiber, fat, cellulose, lignin, ash, caloric value, macroelements, minor elements, trace elements, nitrogen, proteins, amino acids, carbohydrates, and organic functional groups. Approximately 52 000 determinations were provided to professional and technical staff of 15 branch establishments.

New Fibertec and Soxtec equipment was acquired and placed into operation for the determination of fiber and fat contents as part of an effort to upgrade proximate laboratory facilities. Upgraded microcomputer software was put into operation for the acquisition and reporting of amino acid information.

Chemical analysis of maize reference materials was completed by cooperating laboratories. Information provided for concentrations of a number of agriculturally important chemical elements is being assessed, to lead to recommended values.

ELECTRON MICROSCOPE CENTRE

Seventy professional and technical staff of the Ottawa establishments (institutes, stations, centres), six off-campus stations, and eight outside agencies, universities, other government departments, and industry made use of the facilities of the Electron Microscope Centre. Special projects were undertaken for the St. John's West Research Station, Health and Welfare Canada, the Canadian Red Cross, and the Children's Hospital of Eastern Ontario.

The center contributed significantly to 56 manuscripts and graduate dissertations concerned with methodology development; the systematics and phylogeny of insects, nematodes, and fungi; membrane ultrastructure related to stress; ultrastructure of blood platelets; fungal zoospores; fulvic acid – metal interactions; food microstructure; toxin effects on plants; the confirmation of virus-free potato tissue; surface textures of tobacco; fiber morphology; and the microanalyses of soils and soil complexes. Particulars of these publications appear under the individual listings of institutes and stations.

The technical capability of the centre was increased by the addition of a high-resolution scanning microscope (ISI-DS-130), an X-ray spectrometer system (T-N 5500), and a Kontron image analysis system (SEM-IPS). The interfacing of these three pieces of equipment will permit the morphologic and geometric quantification of materials as well as elemental distribution and identification. A Balzer (BAT-400D) freeze-etch device has been installed to facilitate specimen preparation for transmission and high-resolution scanning microscopy. Special methods have been developed for the freezing and replication of very thin samples.

The Electron Microscope Centre hosted visiting workers and graduate students from both home and abroad and has contributed to a variety of educational programs.

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Engineering and Statistical Research Institute, Ottawa, Ontario

PROFESSIONAL STAFF

P.W. Voisey, FI, MechE	Director
H. Pitt, BA	Administration

Energy

P. Van Die, BSc(Eng), MSc	Head of Section
D. LeBlanc, BSc(Eng)	Processing, distributing, retailing
M. Levesque,[2] BSc(Eng)	Conservation—buildings
H.A. Jackson, BSc(Eng), MSc	Greenhouses and solar
E. Manolakis, BSc	Liquid fuels—biogas
D. Sidaway-Wolf, BSc, MSc	Processing, distributing, retailing
C. Vigneault, BSc, MSc	Mechanization—fertilizer

Food Engineering

G.E. Timbers, BSA, MSA, PhD	Head of Section; Food process engineering
D. McGinnis, BApSc(Eng), MSc	Food process engineering

Research Service

E.J. Brach, DEE, DipMil	Head of Section; Electronics
D.J. Buckley, BE, MSc	Electronics

Structures and Mechanization

M. Feldman, BE, MSc	Head of Section; Mechanization Manager of ERDAF contract program
L.P. Heslop, BSc	Mechanization
D. Massé,[2] BSc, MSc	Canada Plan Service design engineer
J.A. Munroe, BSA, MSc, PhD	Structures
P.A. Phillips, BSc(Agr), MSc, PhD	Animal environment
W.S. Reid, BSc(Agr), MSc	Mechanization
J.E. Turnbull, BSA, MSA	Director, Canada Plan Service; Farm structures

Statistical Research

C.J. Williams, BSA, MSc, PhD	Head of Section
M.R. Binns, MA, DipMathStat	Statistics
G. Butler, BMath, MMath	Statistics
P.Y. Jui, BSc, MSc, PhD	Statistics
L.P. Lefkovitch, BSc	Statistics
C.S. Lin, BSc, MSc, PhD	Statistics
B.K. Thompson, BSc, MMath, PhD	Statistics
M.S. Wolynetz, BMath, MMath, PhD	Statistics

W. Watt,[1] BA	Head, Systems and programming
I. Hall,[1] CertInfoProc	Systems and programming
K. Heng,[1] BSc, MAppSc	Systems and programming
J.D. Hobbs,[1] BSc	Systems and programming

Technical Services

J.G. Caron	Head of Section

Departures

K.W. Lievers, BSc(Agr), MSc Transferred to Research Branch Coordination Directorate, 1984	Systems analysis
D. Marshall,[2] BSc(Eng) Resigned February 1985	Energy—biomass, mechanization
G.P. Poushinsky, BSc, MSc Transferred to Research Branch Institutes Directorate, 1984	Head, Statistical Research

VISITING SCIENTIST

R. Garruti, Profa Dra Natural Sciences and Engineering Research Council of Canada grant	Food science

[1]Seconded from Systems and Consulting Directorate.
[2]Educational leave during 1984.

INTRODUCTION

The institute continued its diverse activities, which are illustrated in the following report and by the list of publications provided. The major functions of conducting research and providing advice and services in statistics and engineering continued.

The energy program continued contracting-out to the private sector as the primary means of conducting research and development. The research covers energy technology across the agrifood system from soil to table. In the 6 yr that the program has operated, some notable successes have been achieved, such as in biogas production systems, crop drying, and greenhouses. Some technological areas such as crop residue combustion and solar energy have been proved to have limited application in Canadian agriculture. Contract budget cuts imposed in 1984 will permit a progressive shift to in-house research by 1986.

The food engineering research program provided further results in the form of basic physical property information, processes, instrumentation, and equipment that are being taken up by industry for commercialization.

The structures research program produced further results permitting economies of construction in farm buildings. The output of the Canada Plan Service (CPS) again demonstrated its effectiveness in maintaining a flow of designs for farm buildings and in providing information to farmers and building contractors via provincial extension services. Now in its 31st yr of operation, the CPS has become a respected model within the international agricultural engineering community. Mechanization work continued to focus on the difficult problems of mechanizing horticultural and specialty crops. Undertaking the initial high risks of this research is serving the horticultural industry by creating new crop production opportunities. Notable is the progress made in developing a production system for processing strawberries grown in solid set beds.

The statistical research program provided support and collaboration across all branch research programs. Notable is the recent application of nearest-neighbor analysis and other new methodologies to crop-breeding programs. The provision of proven computer programs for statistical analysis continues to be an important activity, justified by the high level of usage throughout the department. Overall the statisticians are having an incredible impact on the efficiency and accuracy of branch research through improved experimental designs and data analysis, new methodology, and provision of statistical training. The efficiency of the institute's statistical work is also expected to improve with the recent acquisition of a minicomputer.

Other activities, such as the work of the development workshops, maintaining a data base on agricultural engineering research, and provision of maintenance services for scientific equipment, were also maintained.

The development of instruments and equipment for both research programs and departmental food-inspection programs was again fruitful. These new devices are improving the efficiency and accuracy of biological experiments and opening up new avenues of research. Excellent progress has been made on the program to automate food inspection methods through image analysis and robotics technology. The first field trials of instruments are already under way.

Overall a successful program was in place throughout the year, involving 165 in-house research projects and 95 research contracts valued at $10 million. Much work was completed and reported in 120 publications released by the institute. Results from contract work was released in 36 reports placed on the data base maintained by the Canadian Institute for Scientific and Technical Information at the National Research Council of Canada.

Peter W. Voisey
Director

ENERGY

Progress was made in using winter coldness to produce ice for subsequent use in the summer season. Packing vegetables in ice reduces the energy required for vegetable cooling by refrigeration systems. A commercial-scale unit is in operation and a second one is planned. Because of the improved rate of ice production achieved, the technology now has application in the more moderate climatic regions of Canada.

The energy aspects of manure handling and fertilizer were reviewed and reported. An evaluation of the energy savings achieved by installing doors, strip curtains, and night covers as retrofit devices on open multideck freezer cases in food retail stores showed that night covers were the best investment. Results from a project in which the specific heat of cooked chicken is being determined are being compared for several freezing systems. A prototype installation using outside cold air to reduce energy consumption of mechanical refrigeration systems in meat-processing plants has shown potential energy savings, and a full-scale installation is planned.

A comparison of different methods of heating retort pouched foods was made and results were published. A scraped surface heat exchanger was set up for evaluating the suitability for processing various food products. A review of the use of irradiation in the food industry with respect to saving energy and for providing background for undertaking work on this area was completed. The potential of using microwave heating as a means for heating and drying fruits and vegetables is being examined, in comparison with conventional processes. Contracts on microwave roasting of peanuts, use of cold ambient air for refrigeration in meat processing, use of waste heat for preheating processing tomatoes, and development of an energy-efficient extraction process for canola oil progressed. Other current contracts are examining heat recovery in spray drying, use of heat pumps for heating potato storages, construction of a dessicant air dryer, and the application of solar energy at an apple juice facility.

As a result of new technology developed for northern regions, a complex of 10 greenhouses is now in operation using waste heat from a Union Carbide smelter in Chicoutimi. A new retractable insulation system developed has also enhanced the economic viability of northern greenhouse production.

A project to measure the soil heat flux for providing information to design heating and cooling applications is in its 3rd yr and will be used to provide design guidelines for agricultural applications.

A project to more precisely control ventilation in a calf barn found no significant energy savings, but the more stable environment that was maintained reduced losses from death and sickness. Progress on improving the design of heat exchangers for barns and on developing ways to minimize dust fouling and freeze-up is encouraging. Through the contracting-out program, improved technology for the operation of commercial grain dryers was successful in saving energy, and the Ontario provincial government sponsored an incentive program for installing the developed technology.

The program on anaerobic digestion of manure has established the energy production potential through several research projects. There are now about 12 digesters operating on Canadian farms as a result of coordination and cooperation among the government agencies involved. Canada is developing leading expertise and has given a new thrust to the technology. Major work remaining is to improve the reliability, to optimize the operation and design of the systems, and to make effective use of the by-products, particularly the recycling of protein recovered for feed.

Work on biomass combustion is being reduced because it is difficult to find economically viable systems. Future work will focus on demonstration projects where unique conditions such as readily available biomass exist.

A second data acquisition system for a tractor was developed. It has increased data collection, processing, and display capabilities. Data for evaluating the effect of the position of the center of gravity on four-wheel-drive tractor performance was established to evaluate potential fuel economies.

A fuel-alcohol facility is now operational, on a farm-community (or cooperative) scale. It is providing an opportunity to scale up other developing technologies such as feedstock pretreatments. The importance of by-products in making the production of liquid fuels from agriculture economically attractive is a strong focus of the work. The entire liquid-fuels program is a complex of interrelated projects, each one contributing to the overall objective of producing liquid fuels from agriculture. Projects are closely related to other agricultural work and there is potential for spinoffs. For example, separating out corn grain from stover, fermenting the grain to alcohol, and blending the resulting stillage back with stover for animal feed appears to enhance the utilization of the stover by animals. Basic work on cellulose, lignin, and hemicellulose recovery and

improved fermentation processes for alcohol production are providing better understanding of these components.

The processing of Jerusalem artichokes into fermentable sugars is progressing. This technology also contributes toward developing this crop for the production of fructose syrup widely used for food processing.

Submissions were prepared for the department's participation in the national energy program. Budget cuts reduced the energy contracting out program to $4.3 million (from $8 million) for 1985, with additional reductions anticipated. This required developing a new program strategy with less emphasis on new liquid fuels and solar energy research.

FOOD ENGINEERING

Food engineering research resulted in commercialization of both equipment and processes. The Agriculture Canada/Atlantic Bridge Company food blancher won two major awards, the "Gordon Royal Maybee Award" of the Canadian Institute of Food Science and Technology and the "Industrial Achievement Award" of the Institute of Food Technologists (IFT) in the United States. This is the first time that the IFT award has been won by a Canadian invention.

Cryogran, a cryogenic freezing process patented for the department in the 1970s, has become a commercial reality through the efforts of a new licensee, IQF Inc. of Toronto. Cryogran frozen egg products are now available commercially, and considerable growth in the quantities and range of products available is anticipated.

Determination of heat-transfer coefficients in air-over-water retorts was completed. Draft standards on the protocol for pouch processing by retort were sent for consideration to the American Society for Testing Materials and the Canadian General Standards Board.

A pilot-plant unit for continuous microwave processing was installed at a mustard-processing plant in Alberta. This unit, developed in cooperation with the National Research Council, will be tested in a commercial environment with the cooperation of Alberta Agriculture.

A new prototype for forming meat patties was developed and will be tested in cooperation with a firm, with a view to commercialization.

Separation processes were investigated with a liquid cyclone system that was developed in cooperation with the Food Research Institute. Membrane development continued and a supercritical liquid extractor was tested. The latter was used to study separation of butter oil fractions using supercritical CO_2 in cooperation with the Food Science Department at Laval University.

Technology transfer in food texture measurement continued, with participation in a Campbell texture workshop and with input into having the Ottawa starch viscometer commercialized by industry. Research included work with the University of Guelph on fat penetrometers, the development of an oscillating nondestructive gel tester, and the testing of nonconventional Kramer shear cells. The microcomputer program for the acquisition, manipulation, and analysis of texture data has been well accepted and is currently used at several establishments.

ENGINEERING RESEARCH SERVICE

The design and development of instruments and equipment to support research operations across the Branch continued, and a range of equipment was produced to support regulatory work of the department.

The new program of automatic grading and inspection of agricultural products by machine vision is now in place. A standards laboratory for color measurement was established. A shielded dark room for machine vision work with color and black-and-white digital cameras was assembled, as well as a computer with development systems.

The standards laboratory was used to measure the change in color of insect traps due to coating with a nontoxic insect adhesive. A hand-held instrument for grading veal on the basis of color and texture was developed and tested. An electrooptical instrument with a four-color interference filter, used for grading tobacco by texture and color, was also tested.

Various mechanical equipment developed included: an HPLC critical gas extractor, an automatic timing device for malt sample viscometers, a micro syringe mechanism for simultaneous innoculation and withdrawal of 10 cc gas samples from the soil, support tables for pH monitoring systems, a special hot plate shaker, a field soil sterilizer, an anti-roll plate for use with glass knives in a microtome, a photoelectric sensor and alarm system for a film processor, a soil and environment simulation chamber, and a greenhouse lysimeter apparatus. An oviposition event recording system for 1024 birds was installed in a poultry research facility. Based on a two-wire circuit with each station polled by a microprocessor, the new system has other potential industrial applications, for example, alarm systems.

will give a more accurate estimate of dietary vitamin C from tomatoes and will be included in the Canadian nutrient file.

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Research

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Several microcomputer-based instruments were developed; an ultrasonic snow depth gauge is under field testing at the agrometeorological weather station, and a volume measuring system to study individual plants was placed in operation. Several computer interfaces such as for an Alpha Laval Rationmaster and a thermocouple data logger were completed.

STRUCTURES AND MECHANIZATION

Structures

The Canada Plan Service (CPS) completed 28 plan sets in six building categories, as well as producing 62 leaflets. For efficient information release, some less-complicated plans were converted to leaflets containing complete instructions. Emphasis was on beef, dairy, and swine facilities. Roof truss designs were revised, based on data from truss tests to achieve construction economies while maintaining structural safety.

The CPS truss-testing facility was used to simulate snow loads on five doubled gable trusses, 12 m span; the average snow load at failure was 2.64 times the theoretical design load of 1.7 kPa for that particular truss design, with the weakest of the five failing at the 2.43-times design. This excellent performance confirmed the benefits of several design modifications based on previous truss tests.

Multilaminated truss joints (using nails, a steel interior gusset, and two side-plates of plywood) were tested for combined resistance to bending and tension to predict more precisely the performance of roof trusses with semirigid nailed joints.

Two papers on silo gas were presented at an international silo safety conference. Three papers covering penning, planning principles, and manure handling for housing confined animals in Canada were presented at an international conference in Beijing, China. Four contracts were initiated under the agricultural engineering research and development (AERD) program, investigating tingle voltages in animal housing, liquid manure flushing systems, frost penetration around building foundations, and steel roof diaphragms.

Data collection continued on earth-lined manure storages to determine self-sealing effects, snow loads on roofs to obtain better design information, the effectiveness of two-tiered pig pens, and other animal environment-productivity assessments.

Mechanization

The prototype strawberry harvester was improved and completed a full season of work, achieving the targets for machine reliability. Participation continued on the Ontario Processing Strawberry Research Committee, where good progress was achieved in coordinating and advancing the development of a Canadian industry in strawberry processing.

The modified cauliflower tyer achieved 65–90% correctly tied heads in field tests. A fertilizer dispenser for orchards, to deliver the fertilizer in a concentrated band along the tree drip line for improved efficiency of nutrient utilization, was completed and delivered to the Smithfield Experimental Farm. A charcoal slurry applicator was completed and delivered to the Harrow Research Station. Different methods of establishing a rye cover crop after potato harvest were compared, in collaboration with the Charlottetown Research Station.

Data collection continued on cucumber harvesting and soil penetration resistance in a tillage experiment. Development continued on an automatic transplanter. A report was published updating the list of engineering contract research reports available as of June 1984.

Under the agricultural engineering research and development contract program, a multi-pass cucumber harvester, a two-month study and report on a large juice-apple operation in the United States, and a computerized costing program for mechanized dairy manure management were completed. The costing program brought together extensive information and advice from provincial extension specialists and other sources and is now a useful planning tool. The prototype cucumber harvester is not ready for commercialization but was transferred to the Ontario Ministry of Agriculture and Food for further field tests.

STATISTICAL RESEARCH

Statistical support was provided to all branch research objectives through the design and analysis of experiments, maintaining and enhancing computer software, training scientists and support staff in the use of computer software, and research to improve statistical methodology.

Collaborative work included studies on mycotoxins, beef and dairy cattle production, piglet behavior and housing, and fat metabolism in swine. Statistical support was provided to the corn, potato, barley, wheat, and forage crop pro-

grams by the design of breeding protocols, the estimation of genetic parameters, and the design and analysis of numerous experiments and field trials. Major contributions were made to the interpretation of the data from cereal cooperative trials using new procedures to assess variety by location interaction and improving precision using nearest-neighbor techniques and generalized lattices. Collaboration continued on the estimation of true metabolizable energy of poultry feedstuffs and the kinetics of the uptake, disposition, and metabolism of vitamin D in ruminants. The food-quality program was supported through the design and analysis of efficient experiments for sensory evaluation. Work continued on the genetics of general disease resistance, manure storage facilities, crop loss estimation, and weed control programs.

Major changes to the protocol prescribed by the Association of Official Analytical Chemists (AOAC) for the statistical analysis of collaborative trial data resulted from participation on this AOAC committee. Additional theoretical studies of interaction between genotype and environment showed the usefulness of conditional clustering for analyzing this problem. Original studies of fertility trends by nearest-neighbor and other techniques gave useful results for field plot layout to improve experimental precision and efficiency.

Data analysis has been improved by additions to and enhancements of the computer program library. The programs in this library were run about 27 000 times during the year. GENSTAT, a statistical computer package widely used throughout the world, was evaluated and found to be a powerful tool for both the design of experiments and the statistical analysis of data.

TECHNICAL DEVELOPMENT AND SERVICES

The institute workshop continued to support the engineering research programs of the institute by constructing and fabricating prototype equipment under development. Efficiency in the machine shop was improved by the acquisition of a numerically controlled milling machine. Maintenance of research equipment continued at all establishments on the Central Experimental Farm campus. The preventive-maintenance program organized 3 yr ago has proved very effective. Some 1400 work orders for maintenance were completed.

The data base on agricultural engineering research and development was further expanded and now contains 23 000 entries encompassing reports from the agricultural engineering literature. Means are being sought to make the data base accessible to external organizations via computer networks.

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Food Research Institute, Ottawa, Ontario

PROFESSIONAL STAFF

N.W. Tape,[1] BSA, PhD	Director
M.R. Sahasrabudhe, BSc, MSc, PhD	Acting Director
B.R. Maguire	Administrative Officer
K. Lapsley,[2] BSc, MSc	Food Science Services
L. Robichon-Hunt, BSc, MSc	Nutrition Services

Processing Technology and Food Quality

D. Paton, BSc, PhD	Program Leader; Processing technology, extrusion cooking
W.F. Collins, BSc, PhD	Phenolics chemistry
J.D. Jones, BSc, MSc, PhD, CChem, FRSC, FIFST	Oilseed fractionation
C.Y. Ma, BSc, MSc, PhD	Protein functionality
D. Oomah, MSc, PhD	Cereal processing
J.N. Weisz, BSc	Carbohydrate analysis
D.F. Wood,[3] BSc, MSc, PhD	Meat processing
P.J. Wood, BSc, PhD	Carbohydrates

Dairy Products

D.B. Emmons, BSA, MS, PhD	Program Leader; Dairy products
V. Harwalkar, BSc, MSc, PhD	Protein chemistry
R.C. McKellar, BSc, MSc, PhD	Dairy product microbiology
H.W. Modler, BSA, MS, PhD	Dairy products
G. Paquette, BSc	Dairy products
R.P. Sinha, BSc, MSc, PhD	Dairy microbiology

Structure and Sensory Evaluation

I.R. Siddiqui, BSc, MSc, PhD, DSc, C. Chem, FRSC, FCIC	Program Leader; Carbohydrates
D. Froehlich,[4] BSc, MSc	Sensory evaluation
M. Kalab, MSc, PhD	Electron microscopy
L.M. Poste, BASc, Dip Tech	Sensory evaluation
S.H. Yiu, BSc, MSc, PhD	Microscopy

Food Safety and Nutrition

W.J. Mullin, LRIC, PhD	Analytical methodology
R.A. Holley, BSc, PhD	Meat microbiology
L. Nadeau, BSc, MSc	Nutrient analysis
A.M. Paquet, BSc, PhD	Amino acid and peptide chemistry
B. Picard, BSc, MSc, PhD	Microbial biochemistry
L.F. Russell, BSc, MSc	Nutrient analysis
C. Willemot, BSc, MSc, PhD	Lipid biochemistry

Departure

Z. Sabry Resigned 1984	Program Leader; Nutrition

VISITING SCIENTIST

Kazi Shamsuzzaman Natural Sciences and Engineering Research Council postdoctoral fellowship, 1984–1985	Dairy microbiology

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[1]French language training and assignment, September 1984–April 1985.
[2]Transferred to Quebec Region, December 1984.
[3]Seconded to Headquarters, Planning and Coordination Directorate.
[4]Educational leave, University of California, Davis, 1982–1985.

INTRODUCTION

The Food Research Institute is a major center for food research and development in the Research Branch. The institute's aim is to assist the Canadian food industry to become more efficient, productive, and competitive by developing new processes and prototype ingredients and by improving the quality, safety, and nutritional value of foods.

The in-house research programs on dairy products, oilseeds, meats, food safety, and nutrition are geared to the needs of the food industry and the concerns of the consumer. This year a mechanism for direct consultation with the food industry was initiated through an industry liaison committee and through discussions with industry technical committees on specific commodities.

The institute manages a contract research program on processing, distribution, and retail (PDR) and institute scientists act as scientific authorities and evaluators for several contract research projects funded by the federal government.

A Canadian patent was issued under the title "Processing Aqueous-Treated Cereals", resulting from a joint research project with the Ottawa Research Station on oat processing. Dr. Tape chaired the third session of the Codex Committee on Vegetable Proteins and the Canadian delegation was headed by Dr. D.F. Wood.

This report summarizes some of the progress and achievements in 1984. Reprints of research publications and more detailed information can be obtained by writing to the Food Research Institute, Research Branch, Agriculture Canada, Ottawa, Ont. K1A 0C6.

M.R. Sahasrabudhe
Acting Director

FOOD PROCESSING

Extrusion cooking

The mathematical model previously developed to describe the extent of starch breakdown as a function of extrusion operating conditions has been further refined to describe the starch breakdown in terms of intrinsic viscosity and the degree to which the starch is cooked during processing. The revised model is easier to manipulate and more rapid, and it introduces a term related to starch functionality. Wheat starch, vital gluten, and wheat flour solubles were processed in combination in a single-screw extruder. The paste viscosity profiles and degree of cook of the starch component of the products were measured to assess interactive effects. The composite of all three components, simulating a wheat flour, cooked more thoroughly than did the parent wheat flour and gave thicker product pastes. The data suggest that the integral structure of particles of the parent wheat flour imparts a greater resistance to water penetration of the starch granules than would be the case if the individual flour components existed at random in a composite formulation. These results may have a bearing on the control of industrial cooking processes involving multi-component formulations.

Oat proteins

Differential scanning calorimetry (DSC) was used to study the thermal properties of oat globulins under the influence of pH, salts, ethylene glycol, and denaturants. The data reveal the exceptionally high thermal stability of the proteins and show that disulfide bonds and hydrophobic interactions are important in the structural organization of oat globulin polypeptides. Using fluorescent antibodies and high-resolution light microscopy, the oat prolamin (avenin) was shown to be localized in the protein bodies of scutellum cells of dry grain; but 1–3 days after seed germination, a large number of the protein bodies became devoid of prolamin, indicating rapid mobilization of the protein in the germinating seed.

Cereal β-glucans

A rapid and sensitive assay for (1→3)(1→4)-β-D-glucanase in malting barley has been developed. A dyed cereal β-glucan substrate may be prepared simply by addition of Congo Red to crude alkaline extracts of oats or barley. After appropriate washing and drying, the dye–glucan complex may be used as an insoluble substrate for the enzyme. During incubation, dye is released linearly with time and the rate of dye release is proportioned to enzyme activity. Enzyme activity determined by the dye release method correlates well with activity determined by standard viscosity methods. Collaborative studies with Carlsberg Research Laboratories, Copenhagen, are in progress to develop this assay for use by the malting and brewing industry.

Methods for determining cereal β-glucans have been automated. Sugars from hydrolysates of cereal extracts or isolated polysaccharides are separated by high-performance liquid chromatography (HPLC) on Bio-Rad HPX-85 columns using water as eluent. The column effluent is monitored by an automated orcinol assay. The method was used to compare calcofluor-precipitated β-glucan from poor and well-modified malts. Analysis of enzymically released oligosaccharides from residues of extracted oat flour showed that 66% of oat β-glucan was extracted at 45°C by pH 10 carbonate, but that over 90% was extracted at 80°C. Application of the methodology to commercial oat products showed that commercial quick oats contain approximately 3.8% β-glucan, whereas oat bran cereal contains 6–8% β-glucan. Air-classified oat bran prepared under contract at POS pilot plant (Saskatoon) contained 13–15% β-glucan.

Cereal phenolics

Fractionation of solubilized "bound" niacin from oat and wheat bran using gel filtration and ion-exchange chromatography has revealed a number of subunit phenolic-carbohydrate components. The major cationic phenolic-carbohydrates were found to consist of a series of mono- and oligosaccharide derivatives of 2-aminophenol (i.e. 2-hydroxyaniline). Susceptibility to β-glucosidase hydrolysis indicated that these nonreducing glycosides were β-linked through the hydroxyl function of the 2-aminophenol since the amine function is unsubstituted. The smallest member of the series was further purified and characterized as 2-aminophenoxy-1-*O*-β-D-glucopyranoside by mass spectroscopy and nuclear magnetic resonance and confirmed by synthesis.

Several additional hydroxycinnamic acid amides of substituted aminobenzoic acids (i.e. anthranilic acids) have been isolated and identified from oat bran extracts. These include the *N*-ferusoyl, *N*-*p*-coumaroyl, and *N*-caffeoyl derivatives of 5-hydroxyanthranilic acid. Routes to the synthesis of these compounds have been developed and applied to production on a milligram and gram scale for physicochemical, fungistatic, and organoleptic studies. Studies on the physicochemical stability using aqueous and nonaqueous solutions have indicated that although a cyclic form (i.e. substituted 2-styryl-4*H*-3,1-benzoazinone) predominates in nonaqueous solvents, the benzoxazinone ring is rapidly hydrolyzed in aqueous and aqueous-alcohol solutions to the corresponding *N*-aroylamides. Previously reported antifungal activities of the cyclic benzoxazinones may therefore have to be reevaluated in terms of these findings.

Meats

Functionality of oat protein and modified oat protein was determined in comminuted meat systems. Oat globulin (oG), defatted oat globulin (DoG), succinylated oat globulin (SoG), oat protein isolate (oPI), and succinylated oat protein isolate (SoPI) were incorporated at the 5, 10, and 20% replacement levels for meat protein. Cook yields, cohesiveness, and firmness were measured in both beef and pork systems. In the beef system all proteins gave inferior functionality data at all three substitution levels. In the pork system, however, some differences in functionality were observed. The oG and SoPI proteins, at the 5 and 10% levels of substitution, gave functionality data comparable to the all-pork control and only the 20% substitution level was significantly lower. The DoG, SoG, and oPI were all significantly lower than the control at all substitution levels. Further studies are planned to better resolve the reasons for the apparent protein and species difference.

A contract research study on an alternate meat-curing system has resulted in a curing system without the use of nitrite. A patent has been filed for this process.

DAIRY PRODUCTS

Quality of cottage cheese

Mealiness is a problem in curd made from highly heated milk. Whey was acidified to be equivalent to the pH of the interior of curd, where acid is produced more quickly; however, it had no apparent effect on reducing mealiness in the cheese. Various homogenization treatments during the heating of skim milk were tested. Homogenization of ultra-high temperature milk is effective in preventing sediment and the hypothesis was that this would reduce mealiness; however, the treatments had no apparent effect on the curd.

Fortifying skim milk powder with vitamin A

A 2-yr study in collaboration with industry and the University of British Columbia was completed. Antioxidants were found to be necessary to provide reasonable stability over a 1-yr period at 22°C or for 6 mo at 37°C. Dry-blending with stabilized beadlets was the best procedure. Adding stabilized vitamins in oil to skim milk concentrate before spray-drying also gave good stability to regular spray-dried powder. Similar

results were obtained by spraying the stabilized vitamins as an emulsion in skim milk during the instantizing process for instant skim milk.

Whey protein denaturation–aggregation

The thermal properties of β-lactoglobulin, a major whey protein, were studied by differential scanning calorimetry. The effect of several polyols having various hydroxyl contents (e.g. di- and tripolyhydroxyl) and various concentrations (0–50%) upon thermal denaturation of β-lactoglobulin was studied. Most polyols enhanced heat stability as judged by increased T_D (up to 9°C). Ethylene glycol lowered T_D markedly. The modification of thermal stability allows control of denaturation of whey proteins and their functional behavior.

Gelation of milk proteins

Gelation of evaporated milk during its storage has been linked to the practice of cold storage of the concentrate before canning and sterilization. The changes resulting from cold storage of casein micelles were studied. Upon cold storage of heated and unheated casein micelles, some proteins (β-casein) became soluble, and an increase in the surface hydrophobicity and hydration of casein micelles was observed. These changes offer a physicochemical basis for the gelation of sterilized milk.

Microbiological quality of milk

Studies on the mechanism of extracellular proteinase synthesis by psychrotrophic bacteria have revealed that excess carbon, nitrogen, and phosphate are essential for maximum synthesis, suggesting that cells do not produce proteinase in response to nutrient limitation. Divalent cations (e.g. calcium) appear to be necessary for proteinase synthesis, since chelating agents prevent formation of an active enzyme but are less effective against preformed enzyme. A comparison of the hide powder azure and free amino group methods for determining proteolysis in milk was made. Hide powder azure was more sensitive yet less precise than the free amino group method. Spoilage of commercial samples of evaporated milk was linked to acid production by *Enterococcus faecium*. Growth of this microorganism was stimulated by protein hydrolysates resulting from growth and proteinase production by a cocontaminant, *Bacillus subtilis*.

Effect of added phosphate in starter cultures

Addition of phosphate in synthetic media and skim milk accelerated the growth rate and increased significantly the total yields of bacterial cultures. Inorganic phosphate was as effective as organic phosphate. However, for antibiotic resistance, the inorganic phosphate was more effective. The presence of phosphate in the medium increased the resistance of starter cultures to aminoglycoside antibiotics, but sensitized them to penicillin, erythromycin, and tetracycline.

Ultra-high temperature processing of cheese

The continuous process developed for the production of ricotta and Queso cheese was further refined with the new ultra-high temperature (UHT) equipment being used to denature the whey proteins. Denaturation consisted of indirect preheating of the product to 50°C, followed by direct steam injection to obtain temperatures of 95–100°C. Ricotta was successfully prepared from blends of both skim milk and whole milk (10, 15, and 20%) with whey. Depletion of recoverable protein, fat, and solids ranged from 90 to 100% and averaged over 95%. Several Canadian and American firms have expressed an interest in the process.

An all-dairy formulated cream cheese was developed, using either ricotta or Queso Blanco cheese base as the protein source, blended with cultured buttermilk and high-fat sour cream (60–70% butterfat) to yield an excellent-quality cream cheese. The product was hot-packed to give a shelf life of 2–3 mo. The denatured whey proteins in the product absorbed the excess moisture and served to replace stabilizer normally added to most commercial cream cheese.

STRUCTURE AND SENSORY EVALUATION

Carbohydrates

Rigorous purification of certain components of fraction B from the sodium-hydroxide-soluble polysaccharides of tobacco cured-leaf laminae (*Nicotiana tabacum* L. 'Delhi 76'), using a combination of barium hydroxide precipitation and fractionation on DEAE-cellulose (borate) columns, have yielded a galactoxyloglucan. The galactoxyloglucan showed $[\alpha]_D^{24} + 94°$, and had infrared bands at 765, 864, 895, and 934 cm, which are characteristic of amyloids and cellulose. Acid hyrolysis of the amyloid gave galactose, xylose, glucose, and mannose in the molar ratios 1:1:69:0.1. Methylation of the amyloid gave a product that was methanolyzed, hydrolyzed, reduced, acetylated, and examined by gas–liquid chromatography, mass spectroscopy, and chemical ionization methods.

Analysis of the methylation data showed a statistical unit of 63 sugar residues consisting of seven terminal, nonreducing end groups (six D-glucosyl and one D-galactosyl). There are seven residues of D-glucose involved in branching through positions 4 and 6. The remaining 49 nonterminal residues consist of three (1→2)-linked D-xylosyl units and 46 (1→4)-linked D-glucosyl units.

These findings demonstrate that like the previously reported amuloid (galactoxyloglucan), preparations contained small proportions of arabinoxyloglucan. The tobacco amyloid (arabinoxyloglucan) also contains small proportions of the galactoamyloid. Such polysaccharides appear to modify the burning rate of cellulose and ameliorate the associated harshness. Also, these solubilized celluloses could, as by-products isolated during the production of tobacco-leaf proteins, find application in the food industry.

Microstructure

Electron microscopy revealed that the excellent spreadability of a cream cheese spread with a whey protein base was related to its microstructure, which consisted of minute whey protein particles, 100 nm in diameter, and uniform fat globules, 850 470 nm in diameter. The microstructure of a less-spreadable cream cheese spread, based on acid-coagulated milk protein (Queso Blanco), consisted of a compact protein matrix. Casein micelles in this matrix were characterized by a core-and-lining ultrastructure, initially found in glucono-δ-lactone-induced milk gels. The ultrastructure is developed by coagulating hot milk (70–90°C) to pH 5.5. Artefacts, which are developed during scanning electron microscopy of milk products, were further studied and the results published in order to show how the artefacts can be made distinguishable and their development avoidable. In sheep cheeses, manufacturing processes were reflected in the microstructure (oriented versus isotropic).

Collaborative studies contributed to a better understanding of the development of microstructure in heat-coagulated β-lactoglobulin. Other collaborative studies, such as those on filtration of polluted water, effects of proteolytic enzymes on the microstructure of Cheddar cheese, and microstructure of whipped cream, have been continued.

Microscopy

Microscopy was used as a tool to study the distribution of glucosinolates in rapeseed. As there was no specific staining method available, a new histochemical technique for detecting glucosinolates in the rapeseed structure was developed.

N-2,6-trichlor-*p*-benzoquinoneimine (TCQ) was used as the staining reagent. The specificity of TCQ was established by results obtained from paper and gas chromatographic studies of glucosinolates in rapeseed methoanolic extracts using TCQ as the visualizing reagent. Rapeseed hand-cut sections were stained with 1% TCQ (w/v) in absolute methanol containing 0.3 *N* HCl at 60°C for 1–2 min. Microscopic examinations of the stained sections revealed the location and distribution of glucosinolates in the structure of rapeseed.

Glucosinolates were detected within protein bodies of the cotyledonous cells under the established staining condition. As many as 6–10 protein bodies per cell were stained by the reagent.

Sensory evaluation

Investigation into lipid degradation in pork resulted in a clear increase in panelists' scores for off-aroma (warmed-over aroma) from day 0 to day 8. Over the same period the thiobarbituric acid numbers also increased. Three all-dairy formulated cream cheese spreads made from Queso Blanco and ricotta cheese bases were found to be no different from a commercial product with respect to firmness, rate of dissipation, and smoothness. Differences found in saltiness and acidity can be adjusted through formula changes.

Texture profile analysis and instrumental texture measurement techniques were utilized to study the effect of packaging and storage temperature on white navy beans (*P. vulgaris*).

Turkeys, basted and nonbasted, cooked to optimum (85°C) internal temperatures were evaluated. No differences were found in the dark meat. However, the white meat of nonbasted turkeys had less flavor and was less tender and less juicy than that of basted turkeys. White meat of overcooked turkeys was less tender and less juicy than that of optimally cooked turkeys.

FOOD SAFETY AND NUTRITION

Digestibility of dietary proteins

Quantitative *in vitro* determination of the digestibility of synthetic tripeptides (from bovine β-casein) containing D-methionine as an internal residue was carried out using intestinal mucosal peptidases in collaboration with the Department of Food Science, North Carolina State University, Raleigh, N.C. The results show that D-methionine was not released by intestinal enzyme

preparation; neither the amine nor the carboxy-terminal L-amino acid was released when D-methionine was in the internal position in the tripeptide. When methionine-containing tripeptides were treated with intestinal peptidases, complete hydrolysis was observed. Consequently, racemization inhibits not only utilization of those amino acid residues that racemized, but also utilization of the L-forms adjacent to racemized residues in protein structure. Inhibition of biological utilization of proteins by formation of D-amino acids may be two-fold: prevention of complete digestion of the protein; and competitive inhibition of the biological absorption of L-amino acid containing dipeptides by unhydrolyzable D-amino acid containing tripeptides.

Contamination of mustard flour by *Nematospora* yeast

A newly recognized phytopathogenic yeast was found in both oriental (*Brassica juncea*) and yellow (*B. hirta*) mustard seeds grown in western Canada. The new species was named *Nematospora sinecaudu* according to standard botanical procedure. Biochemical testing as well as morphological observations by means of light and scanning electron microscopy were used to establish this organism as the second legitimately recognized species of this genus.

Starter cultures in meat fermentations

Bacteriophage fri inhibited growth and acid production by a narrow range of *Lactobacillus* starter bacteria in nutrient broths. In laboratory sausage the phage-sensitive starters produced sufficient acid to allow production of acceptable sausage in the presence of phage. Dispersal and multiplication of the phage in the meat matrix appeared to be limited and suggested that product failure in the fermented meats industry due to phage infection would be an uncommon event.

Survival of *Staphylococcus* in dried beef

Beef jerky was prepared from both 6-mm-thick slices of inside round steak and corned beef brisket, to which were added cells of *Staphylococcus aureus*. Staphylococci doubled within 2 h of the start of the drying of corned beef slices. About 3–3.5 h was required before corned beef reached a safe water activity of 0.86 and between 1 and 2.5 h before inside-round slices reached this level. Only 15% of all staphylococci initially present survived 8 h of heat-drying, and this figure was reduced to 5% after a week of refrigerated storage of prepared slices. It is thus relatively important that only high-quality meats be used in the manufacture of jerky and that the initial drying be conducted rapidly.

Nitrites

The antimicrobial activity of nitrite is best defined by its property of preventing toxin formation from *C. botulinum*. Work in progress is aimed at the determination of the mechanism of inhibition and the evaluation of potential replacers for nitrite. Nitrite has been shown to inhibit a pathway of adenosine triphosphate (ATP) production in *C. botulinum*. Three other pathways of ATP production by substrate-linked phosphorylation in *C. sporogenes*, a nontoxigenic model for *C. botulinum*, have been identified. The substrates for ATP generation pathways are arginine, threonine, and phenylalanine. Out of the three pathways, one is resistant to nitrite action (arginine as substrate), whereas others have shown sensitivity. Growth experiments have shown that in the presence of arginine sufficient to provide for all the energy requirements of the cell, nitrite can still inhibit growth. This shows that other processes, beside the energy metabolism, are affected by nitrite action and are of primary importance for the determination of the antimicrobial mechanism of nitrite. Preliminary results using nitrite-free cures have shown that sodium hypophosphite and monomethylfumarate are promising compounds. Their utilization can prolong the shelf life of meat at 27°C for more than 2 wk in the presence of spores of *C. botulinum*.

Research has been initiated to provide alternatives to nitrite for meat curing. The mechanism of action of nitrite is being investigated with respect to its antioxidant effect, which retards the development of warmed-over flavor and rancidity. Pork meat lipids were analyzed after various periods of storage at 4°C after cooking. The results showed a decrease in phospholipids and in phospholipid polyunsaturated fatty acids with little change in the triglycerides during warmed-over flavor development. A rapid increase in thiobarbituric acid numbers correlated well with sensory scores for warmed-over aroma and with the lipid changes over time. An unidentified lipid, not detected in fresh meat, accumulated during storage after cooking.

Vitamin C

An HPLC method for determining vitamin C in vegetable samples, particularly tomatoes, is still under development. Good reproducibility has been achieved, internal standards have been evaluated, and results are now being compared with the standard indophenol colorimetric method.

Data on the vitamin C content of imported and domestic tomatoes is being collected to document fluctuations over a 3-yr period. The data

Land Resource Research Institute, Ottawa, Ontario

PROFESSIONAL STAFF

J.S. Clark, BSA, MSc, PhD	Director
J.C. van Schaik, MSc, PhD	Deputy Director
M.B. Trudel	Head, Administration

Soil Resource Inventory and Mapping

J.A. Shields, BSA, MSc, PhD	Soil correlation—Great Plains
C. Tarnocai, BSF, MS	Soil correlation—British Columbia and North

Atlantic Soil Survey (Truro)

F. Hender, BSc	Party leader
D.A. Holmstrom, BSA	Party leader
G.T. Patterson, BSc, MSc	Party leader
H.W. Rees, BSc	Party leader
K.T. Webb, BSc, MSc	Party leader

Quebec Soil Survey (Sainte-Foy)

J.M. Cossette, BSc	Head of Unit
L. Grenon, BSA	Party leader
L. Lamontagne, BSc	Party leader
M.C. Nolin, BSc, MSc	Party leader

Ontario Soil Survey (Guelph)

C.J. Acton, BSA, MSc, PhD	Head of Unit
R.K. Jones, BSc, MSc	Party leader
E.W. Presant, BSA, MSc	Party leader
G.J. Wall, BSA, PhD	Party leader

Manitoba Soil Survey (Winnipeg)

R.E. Smith, BSA, MSc	Head of Unit
R. Eilers, BSA, MSc	Party leader
W.R. Fraser, BSc, MSc	Party leader
W. Michalyna, BSA, MSc, PhD	Party leader
H. Veldhuis, Ing, MSc	Party leader

Saskatchewan Soil Survey (Saskatoon)

D.F. Acton, BSA, MSc, PhD	Head of Unit
A.J. Anderson, BSc	Party leader
W.D. Eilers, BSA, MSc	Party leader
L.M. Kozak, BSA, MSc, PhD	Party leader
G. Padbury, BSA, MSc	Party leader

H.P.W. Rostad, BSA, MSc, PhD	Party leader
H.B. Stonehouse, BSA, MSc	Party leader

Alberta Soil Survey (Edmonton)

W.W. Pettapiece, BSA, MSc, PhD	Head of Unit
J.A. Brierley, BSc	Party leader
G.M. Coen, BSc	Party leader
J.C. Hiley, BA, MA	Party leader
J. Tajek, Eng	Party leader
B.D. Walker, BSc, MSc	Party leader

British Columbia Soil Survey (Vancouver)

T.M. Lord, BSA	Head of Unit
A.J. Green, BSA, MSc	Party leader
D.E. Moon, BSc, PhD	Party leader
C.J. Selby, BSc, MSc	Party leader
K.W.G. Valentine, BSA, MSc, PhD	Party leader
L.J.P. van Vliet, BSA, MSc	Party leader

Soil Classification

J.A. McKeague, BA, BSA, MSc, PhD	Head of Section; Classification
C.A. Fox, BA, MSc, PhD	Micromorphology
P.E.M. Lévesque, BSA, MSA, PhD	Organic soils
S.P. Mathur, BSc, Assoc IARI, PhD	Organic soils
G.C. Topp, BSA, MS, PhD	Physics and water
C. Wang, BSA, MS, PhD	Chemistry
G. Wilson, BSc, MSc, DIC	Engineering
K.C. Wires, BA	Physical structure

Land Use and Evaluation

J. Dumanski, BSA, MSc, PhD	Head of Section
D.R. Coote, MS, PhD	Degradation
J. Culley, BSc, MSc	Water quality
R. DeJong, BSc, MSc, PhD	Water use
E. Huffman, BSc, MA	Land use
B. Kloosterman, BSA, PhD	Data system
K.B. MacDonald, BSA, MSc, PhD	Evaluation
K. Switzer-Howse, BSc	Information

Agrometeorology

J.C. van Schaik, MSc, PhD	Head of Section
J. Boisvert, BSc, MSc	Farm weather service research
A. Bootsma, BSc	Agroclimatological resources
R.L. Desjardins, BSc, MA, PhD	Micrometeorology
L.M. Dwyer, BSc, MSc, PhD	Environmental meteorology
S.M. Edey, BSc	Applications
H.N. Hayhoe, BSc, MS, PhD	Biomathematics
A.R. Mack, BSA, MSc, PhD	Remote sensing
D.W. Stewart, BSA, MSc, PhD	Crop-weather modeling

Departures

J.H. Day, BSA Retired 9 April 1984	Head, Soil resource inventory and mapping
P.K. Heringa, BSc, MSc Retired 12 October 1984	Party leader, Atlantic soil survey

VISITING SCIENTISTS

Uleys Wailanduw Indonesia	Water resource expert
Clovis Lima 1 March 1984 – 1 June 1984, Brazil, Canadian International Development Agency	Peatland inventory
Daniel Lord January–February 1984, Agrometeorology	Postdoctorate

INTRODUCTION

The Land Resource Research Institute (LRRI) continues its responsibility for national programs in land resources and agrometeorologic services. The programs of the institute include the national soil survey program, a supporting program in soil classification research, a program involving studies in land evaluation, agricultural land use, and soil degradation, and an agrometeorological program that includes agrometeorological services, farm weather service, crop-weather modeling, and crop information.

The institute is organized on a regional basis, with soil survey units located in each of the provinces where cooperative survey work is carried out. The central group in Ottawa is responsible for national correlation and map production and for research in the various aspects of soil, water, and agrometeorological disciplines.

This report gives the outcome of the ongoing activities of the institute during 1984. More complete information can be obtained from the Land Resource Research Institute, Research Branch, Agriculture Canada, Ottawa, Ont. K1A 0C6.

J.S. Clark
Director

INSTITUTE ROLES

The activities of LRRI include research, development, and services related to Canada's land resources. These activities not only support other research within the Research Branch but also provide information essential to policy and decision-making for regional and national levels of government, educational institutions, and agribusiness. The institute, in pursuit of these activities, provides leadership and is responsible for a number of national programs related to land, including those outlined below.

Soil inventory. Soil mapping is done by LRRI staff in cooperation with provincial and university personnel throughout the nation. The LRRI through correlation provides quality control on soil maps and reports. Maps are prepared showing the distribution of soils and land capability for various potential uses.

Canada soil information system (CanSIS). Soil survey, soil management, crop yield, and cartographic data are stored in a computerized system so as to be available to users throughout Canada.

Soil taxonomy and interpretations. Improvements are developed in taxonomic and interpretive soil classification systems through research and integration of information from many sources.

Soil degradation. Increased effort has been devoted to the assessment of the degree and extent of soil degradation in all regions of Canada. At present maps and data are being prepared to provide general broad-scale information on soil degradation in all regions. Technologies and procedures for monitoring soil degradation are also being developed.

Land evaluation. Data on soils, climate, agronomy, and economics are being integrated to develop improved methodology for predicting crop yield potentials and assessing the quality of the land resources of Canada for various uses.

Agrometeorological data archive. Agrometeorological data and processing services are provided.

Crop information system and agroclimatic resources. Agroclimatic resources are assessed to provide information for efficient management of agricultural resources. Work on crop information systems has been reduced and present activities are concentrating on maintaining familiarity with new developments.

Committees. LRRI contributes to the integration of land-related and agrometeorology activities of Agriculture Canada and other federal and provincial agencies through participation in a number of committees. These include:

- Canada Committee on Land Resource Services (CCLRS) and the associated expert committees
- Provincial agricultural services coordinating committees and soil survey committees
- Canada Committee on Ecological Land Classification
- Interdepartmental Committee on Land Use
- Interdepartmental Committee on Water
- Geotechnical Committee of the National Research Council and the Peatland Subcommittee

- Canada Advisory Committee on Remote Sensing
- Committee on Great Lakes Water Quality
- Interdepartmental Committee on Air Surveys
- Canada Expert Committee on Agrometeorology
- Atlantic Advisory Committee on Agrometeorology
- Ontario Climate Advisory Committee
- Canadian Advisory Committee on Remote Sensing and associated committees
- Comité de coordination des services agricoles du Canada (CCSAC)
- Commission d'agrométéorologie du Conseil des productions végétales du Québec (CPVQ)
- Atmospheric Environment Service (AES) Task Force on Standard and Nonstandard Climatic Data
- Canadian Committee on Climatic Fluctuations and Man
- Interdepartmental Committee on Telidon

INSTITUTE PROGRESS AND ACHIEVEMENTS

Soil resource inventory and mapping

Newfoundland. The Cormack–Deer Lake soil report was published, and the Red Indian Lake–Burgeo and Terra Nova agricultural development area reports were submitted for publication. Mapping was completed for the Flat Bay and Grandy's Lake–Friars cove areas. Reports for Gander Lake, Green Bay, and Stephenville–Port-aux-Basque were sent to LRRI for editing.

Prince Edward Island. The soil survey report to accompany the maps at a scale of 1:75 000 was submitted for publication. Soil moisture and temperature bench mark sites were monitored bimonthly. A generalized soil landscape map was compiled at a scale of 1:250 000.

New Brunswick. A report was published describing the soils mapped on the Agriculture Canada Research Station at Fredericton. About 15 000 ha were mapped at 1:20 000 on the Woodstock–Florenceville project and a preliminary report was prepared. The Chapman–Minto–Harcourt reconnaissance report was reviewed and submitted to Research Program Service. Report writing continued on the central and northern exploratory project. The soil moisture and temperature monitoring program was expanded to include six more sites. Correlation activities resulted in the finalization of the New Brunswick soils key.

Nova Scotia. Soil maps for Pictou, Colchester, and Hants counties and the Kentville Research Station–Sheffield Mills Research Farm were completed and submitted to cartography for publication. Draft reports for Colchester County and the Kentville Research Station–Sheffield Mills Research Farm were submitted to the Land Resource Research Institute for technical editing. Contracted soil surveys for Cobequid shore, Northumberland shore, and Annapolis Valley have been successfully correlated through their first field season and 29 ortho photo maps at a scale of 1:20 000 were completed. Soil temperature and water table measurements were monitored at 21 sites and the coded data were submitted to CanSIS for manipulation and storage; 21 replacement sites were also installed.

Quebec. Field mapping was completed for the Verchères project and for 25% of the Chambly project; a field tour of the mapped area was attended by 60 persons. The Chapais Experimental Farm near Levis was surveyed and the report was contracted out. A feasibility study was conducted to evaluate the application of microcomputer and commercial software programs for processing soil transect data. Compilation of a generalized soil landscape map (1:1 million scale) was completed for the agricultural region.

Ontario. Soil maps with descriptive legends were published for Sault Sainte Marie–Blind River (41J,K), Kenora–Dryden (52E, F), and International Falls–Rainy River (52C, D) map sheets. Soil maps were printed for the Haldimand –Norfolk region and the report was submitted for printing. Maps for North Bay (31L), Gogama (41P), and Ville Marie (31M) project areas were submitted for final cartographic preparation. About 84 000 ha were mapped in the Niagara region and 12 000 ha in Middlesex county; preliminary maps were prepared. Improved soil interpretations for horticultural and special field crops were developed, and interpretations for erodibility were enhanced through development of a rainfall simulator and procedures for field measurement of soil erosion. A report was finalized on soil interpretations and soil training for forest land management in southern Ontario; task force involvement commenced for the identification of prime sites for northern forest development.

Manitoba. Reports were published for the Roblin and the Notre Dame–Rathwell–Treherne project. Field mapping was completed for approximately 147 700 ha at 1:20 000 and 1:50 000 scale in portions of the municipalities of Dufferin–Grey, D60; Lorne, D63; Shellmouth, D64; South Cypress, D65; Swan River, D66; and

Springfield, D67; and at nine waste sites and acid-rain-testing sites near Thompson, Man. Reports were completed to publication stage for Labroquerie–Sainte-Anne, D49; Westbourne, D51; villages of Altona, Emerson, Gretna, Ile des Chenes, Landmark, Letellier, Rosennart, and Saint-Jean, D53; Sainte Rose, D55; Souris, Wawanesa, and Virden, D56; Interlake villages, D57; Minnedosa and Hallboro, D58; and Baudry Park, D59. Development of irrigation suitability and salinity classification criteria was continued in cooperation with Prairie Farm Rehabilitation Administration and prairie region survey units. Field measurements were conducted *in situ* to measure field capacity and bulk density required for calculating available water-holding capacity of loam, glacial till, and lacustrine clay in southern Manitoba.

Saskatchewan. Mapping was completed on approximately 230 000 ha in the Melville–Riding Mountain area and 320 000 ha in the Battlefords area, and was initiated on an additional 425 000 ha in the Battlefords area. A new highly interpretive report format was published for Wolseley. Editing of reports and extended legends has been completed on an additional nine municipalities, and maps have been compiled, extended legends prepared, and the first draft of reports written for 12 more municipalities. Reports were also published for the Swift Current and Green Lake–Waterhen map areas. *In situ* field studies were conducted to determine available water capacity and permeability of selected soils. The dynamics of the shrink–swell process in clay soils was clearly established by micromorphology and measurements of field cracking; recommendations relative to the classification of these soils were developed. Measurements of the buildup and dissipation of groundwater mounds beneath potholes in relation to the associated geochemical processes were instrumental in the development of models for mapping soil salinity.

Alberta. Reports for Revelstoke, Kootenay, and Glacier national parks were completed and submitted to Parks Canada. A field survey was completed for the last 100 000 ha in the Cardston county survey, and interim maps were compiled and submitted to the cartography unit. Maps for Medicine Hat (72L) were also submitted to the cartography unit and interim copies of all maps were made available on request. A project outline was prepared for the Pincher Creek survey area and a joint project was negotiated with the Alberta Research Council for a survey of Flagstaff County in eastcentral Alberta. The computerized land base project on a quarter section basis (called SIDMAP) was documented and made available to other agencies. This joint project with Alberta Agriculture has greatly enhanced awareness of an interest in using soil survey information in Alberta; a paper was also presented on this project at the Canadian Society of Soil Science meetings. Considerable progress was made toward establishment of a committee to coordinate all soil and land inventory work in the province. It has representation from four government departments—Agriculture, Energy and Natural Resources, Environment, and Municipal Affairs—as well as the Alberta Research Council, the University of Alberta (Soils Department), and Agriculture Canada (Soil Survey). Correlation activities saw field reviews conducted in the Paintearth, Cardston, and Pincher Creek areas. The physiographic map (1:1.5 million scale) was completed and submitted for publication.

British Columbia. Reports describing soils on Saltspring Island, Fender Islands, and the Mill–Woodfibre Creek area were submitted for publication. The Power River inventory and peatland systems reports were submitted to Research Program Service for editing. A report was drafted for Taseko Lakes and the agricultural capability map was completed for the Upper Pine Valley. High intensity surveys were conducted on three Indian reserves in the Peace River area and two reserves in northcentral British Columbia. Research was conducted into survey intensity level specifications, and two papers were published. The CanSIS soil name file for British Columbia was amended and revised. Contracts were managed for the preparation of Williams Lake and Nazko soil reports and for the compilation of generalized soil landscape maps (1:500 000 scale) of the southern agricultural area.

Yukon Territory. Twenty thousand hectares were mapped at a scale of 1:20 000 in the Takhini and Carcross valleys of the Whitehorse project area and preliminary maps were made available to requesting agencies. An exploratory survey was conducted to characterize soil landscapes along the Dempster Highway in the Richardson Mountains–Eagle Plains region and a report was prepared. In cooperation with the Yukon Department of Municipal Affairs and Beaverlodge Research Station, the 1st yr of a territorial crop and fertility trial demonstration project was successfully completed. The 2nd yr of results from the soil testing program for commercial farmers were summarized and presented to the local agricultural association. Soil benchmark sites were established at 10 locations to monitor soil temperature and water.

Northwest Territories. The field work on the southern Keewatin soil survey project was com-

pleted and a preliminary soil map of this area was prepared. The first drafts of the soil reports and soil maps of the Great Bear–Slave River and the Bathurst–Cornwallis Island soil survey map areas were completed. On-site adjustment and replacement of thermistors on the Inuvik temperature sites were completed. Soil temperatures continued to be monitored year-round on these sites. Evaluation of the first 2.5 yr of soil temperature data was completed and published.

Ottawa. Correlation field reviews were conducted for a number of regional projects and the national soil-names file was updated. Map legends and soil reports submitted for publication were edited. The small-scale generalized soil landscape maps (1:1 million scale) of Saskatchewan and Manitoba were submitted for publication and maps at 1:500 000 scale were compiled for New Brunswick, Nova Scotia, and the Peace River area in British Columbia. Statistics Canada enumeration area data were added to the extended legend of the Saskatchewan small-scale map. Maps showing aridity indices for wheat and perennial crops based on soil and climatic parameters were published for Saskatchewan. The first four sections (100–400) of the *Soil Survey Handbook*, outlining surveys in Canada and their planning and operations, were submitted for printing and section 600 (*Soil Survey Investigations*) was reviewed by the editorial lead committee.

Cartography. The cartographic unit completed 69 maps for Agriculture Canada and Environment Canada and forwarded them for printing according to schedule. The *British Columbia Grape Atlas* was produced and printed, as were 13 other special projects. The unit also completed 357 miscellaneous jobs for Research Branch staff. Improvements to the CanSIS software were completed and will result in an increase in productivity and cost efficiency in future years. Consultation and advice was provided to the Nova Scotia Soil Survey unit concerning cartographic and CanSIS requirements for mapping projects under contract. A total of 123 maps were completed for CanSIS and 383 derivative maps were also prepared.

Peatland Inventory. This project, supported by the National Research Council of Canada (NRC) and Energy Mines and Resources Canada (EMR), was in its third and final year. The preliminary reports and accompanying peatland maps of the Pacific Coast of British Columbia and the Saint Lawrence Lowland were completed. The study that assessed the peatland resources of Canada was completed and published by NRC. Maps showing wetland regions and wetland distribution in Canada have been finalized and are in the process of being published by EMR in the *National Atlas of Canada*. A national wetland data bank has been developed to facilitate the storage and analysis of peatland information.

The analysis of the data on Folisols and the papers dealing with the characteristics and classification of Folisols have been completed and presented to the soil classification working group of the Expert Committee on Soil Survey. In addition to this, a paper dealing with the micromorphology of organic soils and organic layers has been completed and published.

Preparation of the 1:250 000 scale peatland maps of the Mackenzie Valley and northern Yukon was completed and the evaluation of site-specific background data from various sources was initiated.

Development of the motor-driven peat auger, which will provide easier and more efficient sampling of frozen peats in contrast to the manual and less efficient method used to date, has been completed and successfully tested.

Soil classification

The Soil Classification Section does research to improve soil classification and soil interpretations, and provides field and laboratory services for all sections of LRRI. Progress is reported for the projects concerning soil water and structure, mineral soils, and organic soils, and for the service functions.

Soil water and structure. The pilot industry–laboratory program (PILP) contract was completed and the instrument for reflectrometry analysis for moisture in soil (IRAMS) is being manufactured and sold by Foundation Instruments Inc. of Ottawa. Evaluation in the field over one growing season showed that the reflectrometry technique for measuring soil water is as accurate as and much more convenient than the usual sampling method.

A closed-top infiltrometer for use on a single ring was developed for measuring infiltration of water into soil under readily adjusted heads. Use of a low negative head resulted in the rapid attainment of reproducible values and avoided uncontrolled flow into cracks. The technique is especially useful in structured soils in which reliable infiltration from measurements at positive heads are difficult to obtain.

Horizontal saturated hydraulic conductivity (K_{sat}) of soils in the Ottawa area was found to range from 0.3 to 9 times vertical K_{sat} values for the same horizons. High horizontal K_{sat} values were associated with stratified materials and high vertical K_{sat} values with abundant earthworm channels. Estimates of horizontal K_{sat} as one of eight classes, from guidelines based on soil mor-

phology, were within one class of the measured class in more than 80% of cases.

Approaches used by soil survey organizations of six countries for characterizing and interpreting the air–water properties of soils were evaluated. Improvements could be made in Canada by adjusting the upper limit to −5 or −10 kPa for estimating the capacity of soils to retain water according to plant rooting habits, and by improving guidelines for estimating saturated hydraulic conductivity and aeration from soil morphology by checking against field measurements.

Vane shear strength of a clayey soil within a delineation on a soil map was shown to be variable. The results for a soil thought to be uniform show the need for assessment of variability and adequate replication of shear strength measurements to be used in soil survey interpretations.

Improvements were made in procedures for progressive measurements of soil shrinkage as the soil dries and for exchanging soil water by acetone prior to impregnation with resins and preparation of thin sections for microstructure studies. Seven research papers were published or are in press.

Mineral soils. Podzolic soils in an area of the southern Laurentian Highlands were so variable in depth to bedrocks that naming mapping units in terms of series is not feasible even at a scale of 1:20 000. The soils could be classified appropriately at the family level as dominantly Orthic Ferro-Humic Podzols, coarse loamy, mixed, cold, humid family, with some shallow to extremely shallow lithic families of the same subgroup, and minor inclusions of similar families of Gleyed Ferro-Humic Podzols. Designating soils of such mapping units as a single series is misleading to interpreters of soil survey information.

Inorganic forms accounted for most of the amorphous Al, Fe, and Si in B horizons of some sandy Podzolic soils from Quebec and some sandy Brunisolic soils from Ontario. This provides further evidence in support of the hypothesis that translocation of inorganic forms of Al, Fe, and Si plays a significant role in podzolization. Translocation of Al and Fe as organic complexes is not discounted but the common belief that it is the major mechanism in podzolization is open to question.

Properties of two Nova Scotian soils developed in tills of different ages were found to be similar, with the exception of color and thickness of sola. It is concluded that both tills are of Late Wisconsin age and that the color difference is due to different sithological sources of the tills.

Developments in concepts of Gleysolic soils and information on problems with criteria for classifying these soils were summarized. Based on information from all regions of Canada, modified criteria were proposed and tested on some problem soils in British Columbia. The modified criteria resolved several problems but further testing of them throughout Canada is required.

Several methods used in the chemical characterization of the classification of soils were developed or modified and tested. Evaluation of several field tests for differentiating podzolic B horizons showed that color of an HCl–HF extract was better than other, more complex tests proposed. For borderline soils, however, laboratory analysis is recommended to resolve questions of classification. A related study showed that hydrochloric acid hydroxylamine has some advantages over the commonly used acid ammonium oxalate as an extractant of amorphous forms of Fe and Al in soils. Solutions of ethylenediaminetetraacetic acid (EDTA), however, were shown to be inferior to currently used selective extractants for both amorphous and organic forms of Fe and Al in soils. A method for total fluoride determination was tested and applied to reference soil samples; fluorine ranges from 90 to 1000 mg/kg.

New engineering interpretation sheets were developed for mineral soils to facilitate engineering soil classification from soil survey data. Pedotechnical interpretations were compiled for organic soils to facilitate information transfer between soil surveyors and engineers.

A total of eight research and three miscellaneous papers were published or are in press.

Organic soils. Hydrological and agronomic characterization of organic soils toward development of a national land use capability rating for organic soils in Canada indicated that deeper layers of organic soils transmit water more slowly than shallow layers, even when degree of decomposition does not increase with depth; and most of the 12 mineral sublayers of organic soils in Canada can be productive and manageable when mixed in certain proportions with their organic overlay. A new instrument, a microcomputer capacitor piezometer system, was designed, built, and compared with field instruments that were used to complete a survey of hydrological properties of shallow organic soils and their mineral sublayers across the country. A detailed investigation on the Keswick marsh showed that fluctuating water tables in cultivated organic soils transport partly degraded and humified organic materials.

To meet the need for an economic and effective source of N, P, K, Ca, and minor elements for fertilizing nutrient-poor sphagnum peats, methodology was developed for preparing high quality

composts from fish scrap, crab scrap, and seaweeds by enveloping them in sphagnum peat. The acidic peat absorbed the ammonia produced by the decomposing fish and crab scraps. The fibrous nature of the peat, high biodegradability of all the materials, and the special design of the manually prepared aboveground compost heaps (naturally ventilated through reusable soil pipes), promoted rapid aerobic thermophilic activity, so that no malodors were produced. The high water and heat retention properties of the peat obviated the need for opening, watering, and turning of the compost heaps. The composts produced are earthy in smell, granular, near neutral in pH, dark brown, and rich in both immediately and slowly available nutrients.

A study of Folisols, soils with thick layers of forest litter (folic), in northern Vancouver Island showed that the thickness of folic material was highly variable over short distances. Thick folic layers were commonly associated with decomposing wood and they tended to occur on lower slope positions. Data from this and previous studies led to the decision to classify soils with more than 40 cm of folic material overlying mineral material in the Folisol great group of the Organic order.

A total of six research and three miscellaneous papers were published or are in press.

Field and laboratory services. Greenhouse and field experiments were maintained, samples were prepared for analysis, and chemical and physical analysis of 3500 soil and water samples was completed for a total of some 20 LRRI scientists in soil survey units and in Ottawa. Recently purchased major automated instruments, namely the Leco carbon, hydrogen, and nitrogen determinator, an autoanalyzer, and an atomic absorption spectrophotometer with programmable sampler, were brought into full operation and have made it possible to provide a more efficient analytical service. A methods manual was published and the precision and accuracy of soil determinations of C and N by the new equipment were tested and found to be superior to those achieved by previous methods used in the laboratory.

Land use and evaluation

The land use and evaluation program undertakes to develop improved techniques for integrating and interpreting soil climate, landform, agronomic, and economic data to evaluate the production potential and degradation hazards of land under alternate agricultural uses. Progress for each of the projects is as follows.

Land evaluation and crop production. Estimates of long-term, actual crop yields for five crops in Canada have been compiled and documented. Five-year running means and time trends have been calculated for corn and spring wheat, and fluctuations in yield are being researched. A crop growth model for spring wheat has been completed in Manitoba, and work has begun on compiling an integrated soil–climate data base for application of the model. The soil salinity file for Manitoba was expanded, and a revised irrigation suitability classification was prepared. A detailed soil inventory data base (1:250 000) for Alberta (SIDMAP) was finalized and documented, and a series of derivatives was produced. Procedures for automated computer legends have been implemented in Saskatchewan.

An evaluation of the SPAW soil–plant–air–water (SPAW) model using Canadian data was encouraging. The model calculates soil water changes throughout the growing season with a minimum of measured values. A procedure for calculating soil moisture in high water table situations was implemented. Long-term soil water reserves for a wheat–fallow rotation in southern Saskatchewan were calculated, and maps produced. The efficiency of summerfallow to recharge available soil water was estimated to be less than 16%. Summerfallow ratios were related to physical and economic data in western Canada.

A procedure was developed for identifying agricultural priority areas at a municipal level (1:50 000). This utilizes a combination of agricultural land use and soil survey data. It is an example of detailed land evaluation and is complementary to the broad-scale, supply-oriented studies done at the University of Guelph. The Niagara land use report was finalized and submitted for publication. This relates the economic performance of various agricultural activities to physical land factors. The Guelph land evaluation group has identified data requirements for national land evaluation and is proceeding to compile the necessary integrated data bases.

A classification procedure for farm-level cropping systems from census acreage data has been developed. This technique, which estimates land-based economic analyses at the regional level, is being used in several studies of agriculture in eastern Canada. A very detailed version of the sorting program is being used to augment field data in the Haldiman–Norfolk land use systems project, and a more general version is being applied to a land degradation study in central and eastern Canada.

Forest land productivity in Canada was evaluated at a broad scale using a physical crop growth model. Generally good agreement was achieved with available forest yield data. Seven scientific papers and bulletins were prepared for publication.

Land resource protection. Maps have been prepared that show the risk of water erosion in southern Ontario and the Peace River region of British Columbia, and the risk of wind erosion in Manitoba and Saskatchewan. Field, laboratory, and modeling studies have demonstrated the greater water erodibility of soils when they are freshly thawed in the spring, and the high risk of wind erosion of dry, snow-free soils in winter.

Acid rain and nitrogen fertilizers have been compared using a model of soil acidification processes. Nitrogen fertilizer was found to be the greater source of acidity in the agricultural soils of all regions of Canada west of Quebec. The beneficial effects on agricultural land of the nitrogen and sulfur in acid rain were found to be over 10 times greater than the cost of lime to neutralize the acidity they cause.

The role of pipe drains in modifying water tables has been evaluated in an important eastern Ontario soil, and equations predicting drain spacing were compared. An experiment has been established in the northern Ontario Clay Belt to study the effectiveness of alternative drainage systems. Erosion and water quality have been measured in open-channel outlet drains in an unstable eastern Ontario soil. Major improvements were demonstrated with the use of vegetation, groundwater interception pipes, and bank slope angles.

Factors for application of the universal soil loss equation (USLE) have been calculated and put on computer for southwestern Ontario, Alberta, and part of the British Columbia portion of the Peace River area.

Studies of soil erodibility have continued in the field using a rainfall simulator, as have studies of the effects of herbicide use and zero-tillage on soil structure. Seven scientific papers and reports have been prepared.

Canada soil information system (CanSIS). Work is in progress to transfer cartographic software from the IBM system on Data Crown to the VAX computers in Agriculture Canada. This offers the potential of reducing both the time and costs involved in producing interpretive maps. Software is being developed to eliminate the restriction on the number of map symbols allowed and the physical size of the map.

The testing and implementation of the standalone digitizing work station have been completed for the map-digitizing portion of the system. A regional installation has been effected in Nova Scotia and is progressing in Manitoba and Saskatchewan. Software for the map analysis (output) is being developed under contract and will be tested in the new year.

All the national data files have been reformated to one or a series of RAPID relations and efforts are being focused on the development of output reports and flexible output...ing procedures. A wide range of report types have been developed for the soil data (DETAIL) file and the wetlands registry. Work is currently under way to refine and consolidate these into a flexible reporting system and to allow for a wide range of statistical manipulations and summaries. It will also facilitate transfer of data to other computer systems. Final products will be published in a user's manual in the future.

The general CanSIS user's manual and user's output manual for the soil performance and management file of CanSIS have been published. These represent major steps toward complete sys-tr... documentation.

...here has been rapid development of interest in ...icrocomputers for regional offices over the past year. Thus major efforts were directed toward the development of an overall institute electronic data processing policy, preparation of equipment acquisition plans up to 1987, and preparation of requisitions and justification for the electronic data processing hardware and software to be acquired.

Agrometeorology

Research and development within the Agrometeorology Section is concerned with characterizing weather and climate as it relates to agriculture, in order to provide a quantitative basis for efficient use of Canada's limiting climate resources and to provide for more informed decision-making on weather-sensitive agricultural operations. Evidence is accumulating to suggest that we are likely to experience periods of climatic variability and possibly climate change due to increasing carbon dioxide levels. Research to increase our understanding and to develop methodologies to assess crop response to environmental factors is a prerequisite if food production in Canada is to effectively adjust to the possible complex environmental changes. Development of methodologies to assess agroclimatic resources for normal climate and for variable or changing climate conditions need increasing support. The growing cost of energy and the desirability of optimizing the application of chemical control for crop pests and disease make the development and dissemination of agrometeorological

indices applicable for decision making for weather-sensitive agricultural operations an important priority.

Crop environment assessment. Procedures for operationally estimating yields of cereal crops under different cultural management practices from daily meteorological data and current soil water reserves have been developed for projecting conservative production estimates. By late June 1984, in the Brown Soil Zone, yields of 1.2 t/ha for wheat on fallow and of 0.7–0.8 t/ha on stubbleland were estimated. Final reported production yields were 1 t/ha. By comparison, yields of 1.6–1.8 t/ha in the Dark Brown Soil Zone were estimated. Final reported production yields were 1.6 t/ha. During this time when dry conditions were prevailing in the southern prairies, crop yields of 2.0–2.4 t/ha in the Black Soil Zone were estimated. Simultaneously, imagery for Saskatchewan was acquired in mid July from the polar-orbiting (daily) satellite operated by the National Oceanic and Atmospheric Administration. It outlined the boundaries of the drought areas, which extended south of Yorkton, Quill Lake, North Battleford, and Kindersley. These areas also coincided with soil moisture reserves as estimated from daily meteorological data for sites having less than 75% of normal soil water reserves for continuously cropped lands (25 June). The wheat yield – protein model was modified to calculate conserved over-winter soil moisture for wheat grown on both fallow and stubble land. Other modifications were introduced to increase sensitivity for unusually dry years based on crop data obtained from 1961 to 1978.

Field monitoring of seven test areas provided data on crops and crop growing conditions in the Prairie Provinces for analyses of the thematic mapper data from Landsat and from airborne radar imagery acquired in the X, C, and L band wavelengths. High-resolution airborne multiband spectrometer data were obtained for defining future agricultural optical sensor systems. Analyses of changes in water bodies in eastern Saskatchewan over a period of years using Landsat data in relation to crop yields indicated a complex relationship between water-body distribution, previous environmental and weather conditions, and current season's crop conditions. Results from ground-based spectrometer studies show that measurements of irradiance values for the red and far-red bands taken under cloudy conditions are more constant and approximately 10% larger than measurements taken during sunny conditions. Also, under windy conditions, the red reflectance band shows larger variability than the far-red one. The sensitivity of a canopy to wind is dependent, however, on its geometrical configuration. Under such conditions, it is important to use the median value rather than the mean value. These results may be useful for future detailed analyses of satellite imagery.

Rates of biomass production of corn under field conditions have been estimated for 3 yr from the net absorption of carbon dioxide. The total biomass production for each growing season was determined by calculating gross photosynthesis, plant respiration, and soil respiration from hourly measurements of easily observed environmental factors and asssociated functional relationships.

The potential of measuring crop growth and water use for areal applications was demonstrated using an airborne analyses system developed in cooperation with the Engineering and Statistical Research Institute and the National Aeronautical Establishment of the National Research Council by: comparing the rate of growth of canola, flax, wheat, and corn from CO_2 flux at 25 m above the crops; providing a rapid estimate of the reduction in growth potential of an area damaged by a hailstorm by measuring the CO_2 flux over the area; and estimating regional actual evapotranspiration for water balance studies.

Agroclimatic resource assessment. Results of assessments of agroclimatic resources of the Atlantic Region were incorporated into extension publications for improved guidelines on cutting management of forage crops and optimum seeding dates of winter wheat. These recommendations will promote improved forage quality or improved yield, or both, through better management. In cooperation with Environment Canada, historical archives of daily depth of snow on ground are being upgraded and expanded for all agricultural regions in Canada. The improved data base will facilitate more detailed assessment of conditions for overwintering crops.

A report was completed on the possible impact of climatic change on crop production in various regions of Canada, in cooperation with the Crop Production Division of the Production Development Directorate and the Land Use and Evaluation Section of LRRI. Results of this study suggest that a warming trend in climate without changes in precipitation could cause a decline in yields of many crops in most regions due to higher moisture stress.

Preparation of detailed frost maps for about one-third of the agricultural land area of Prince Edward Island was completed. Information on dates of last spring and first autumn freeze and freeze-free period are overlaid on 74 orthophotobase map sheets at a scale of 1:10 000. The maps

will be made available to farmers for management decisions relating to frost-sensitive crops.

Studies continued on the relationships between the physical environment and crop growth and development. Field data on growth and phenological development of corn, soybeans, and barley were obtained for the 3rd yr at four sites. A method of estimating corn leaf stage and expansion from environmental parameters (temperature and moisture) was developed and tested against field data on sandy loam and clay soils. Growth and water relations of barley in sandy loam and clay loam soils were monitored in a greenhouse environment. A nonlinear model was developed and fitted to corn growth data. This model has the potential for being used in wide area estimates of crop growth and yield. Developmental work on detailed corn growth modeling continued by incorporating leaf development and transpiration functions into the model. Water stress conditioning of corn was studied by monitoring changes in osmotic potential under field and controlled conditions.

Improved simulations of the soil water regime near the surface boundary were achieved by using new numerical schemes at the soil surface in the Hayhoe–de Jong soil moisture model. The effect of using 30 yr of daily weather data as opposed to climatic normal data as input into three soil water models of increasing complexity was studied. The models used for this purpose included the aridity index of wheat, the versatile soil moisture budget, and the Hayhoe–de Jong soil moisture model. Continued improvements in soil water modeling will improve our ability to characterize soil climatic regimes for agriculture, for estimating crop yield and evaluating management practices.

Operations management. The Agrometeorology Section is actively involved in research to develop and demonstrate the usefulness of indices and parameters that integrate weather and soil conditions into decision-making aids for agricultural production. As part of this project current weather conditions and derived soil moisture were monitored on a weekly and monthly basis during the year for the Prairie Provinces. Eighteen soil moisture evaluation reports were produced, together with 352 manuscript maps for reproduction on the Grassroots videotex services. Development work was carried out on an improved crop stress index for wheat. Coefficients for each crop district related to five phenological stages were developed. Current computer weather data files for Ontario and the Prairie Provinces were updated on a weekly basis for use by regional agricultural researchers for near-real-time weather-based estimates of insect populations, disease development, and crop maturity. A 6-mo trial of a microprocessor-based data logger at the Agriculture Canada weather site in Ottawa was completed. A microcomputer with automatic dialing capability was used to automatically retrieve data from the weather site at night and on weekends via the telephone line. This system can potentially reduce manpower requirements and increase the availability of current weather data for computer updating of agrometeorological indices and models. Provincial and farm groups were visited in Manitoba, Saskatchewan, Alberta, and British Columbia, with a view to improving local farm weather services through incorporation of agrometeorological indices related to pests, diseases, crop maturity, and hay-drying potential.

A network of soil moisture observations was established in three areas in Quebec, in cooperation with the Commission d'agrométéorologie du Québec. The recommended model was calibrated and implemented at Ville Saint-Laurent. A function to estimate the contribution of the water table to soil moisture was developed. A cooperative project with the Saint-Jean Research Station to develop an apple bud survival function and an apple growth function was initiated.

A new low-cost leaf wetness sensor was compared with the standard instrument for measuring wetting duration, the Hiltner dew balance, and a commercial resistance-type sensor. The results were most encouraging and suggest that this new sensor could be useful in monitoring leaf-wetting duration for prediction of development and control of disease for fruit and vegetable production.

Field monitoring of winter and spring environmental and soil conditions was continued, to increase the data available to evaluate frost depth sensors and develop and test numerical models of soil temperature and freeze–thaw processes. The new frost probe was adapted for automatic recording with a CR5 data logger. In addition, a different electrode configuration was designed and field tested. A numerical model of heat flow in the snow for the case where snow depth and density is specified was formulated and integrated with a soil heat flow model. The heat flow model was successfully applied for comparison with frost depth estimating from the electrical frost probe. Design modifications were made to the sonic snow-depth sensor. It was installed at the Agriculture Canada weather site in Ottawa for further evaluation and comparison with standard measurements.

A field experiment was carried out monitoring the response of strawberries to irrigation, which

was scheduled according to three different criteria. A greenhouse experiment was carried out to monitor B-gauge response to that of other indicators of water stress.

In a cooperative study with the Saskatoon Research Station multiple regressions relating weather conditions in Saskatchewan on a rural municipality basis for the years 1943 to 1981 to fluctuations in combined field and combined roadside grasshopper populations were used to interpret the spatial growth and decline indicated in three-dimensional plots. A study was completed to determine the change in the drying index over the growing season at selected sites in the Maritimes.

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Research Program Service, Ottawa, Ontario

PROFESSIONAL STAFF

Administration

E. Larmond, BSc	Acting Director
D.W. Friel	Administration and awards
W.L. Fettes	Branch liaison

Graphics

C.N. Halchuk	Art and design
W.G. Wilson	Photography

Scientific Editing

J.A. Perrin,[1] BSc	Head of Section
D.M. Archibald, BA	Acting Head of Section
S.V. Balchin	Editing
N. Rousseau, BA, MA	Editing
S.M. Rudnitski, BSc	Editing
D.R. Sabourin, BA	Editing
F. Smith, BA	Editing
J.M. Tomlinson, BA, MA	Editing

Scientific Information Retrieval

J. Taky, BA, BSc	Head of Section
P. Beauchamp, BSc, MSc	Herbicides
J.S. Kelleher, BSc, MSc, PhD	Biocontrol
H.S. Krehm, BA, MA, PhD	Fungicides and insecticides
C.D. Laing, BSc, MSc	Inventory and systems
R. McNeil, BSc	Inventory and systems

Departures

R. Makowski, BSc, MSc Educational leave, September 1983	Scientific information
J. Whelan, BSc Transferred to Energy, Mines and Resources Canada, 27 June 1984	Systems

[1]Seconded to Branch Executive.

INTRODUCTION

Research Program Service supports research and development in the branch by maintaining computerized scientific and technical information systems, providing publications services, and administering branch awards and international scientific exchange programs. The service is divided into four sections: Administration, which contains the awards, branch liaison, and word processing units; Graphics, which contains the art and design and the photography units; Scientific Editing, which comprises English and French editors; and Scientific Information Retrieval, which contains the biocontrol, inventory and systems, and pesticides units.

The Scientific Information Retrieval Section has put into service two new components to the Pesticide Research Information System, namely, the pesticide use index and the pesticide residues. The Administration Section continued to administer the program for operating grants and visiting fellowships, and to coordinate international missions and visits and exchange programs with the USSR, Brazil, Czechoslovakia, France, the Federal Republic of Germany, Japan, and the United Kingdom. Research Branch staff was informed of the news, happenings, and accomplishments through the nine issues of *Tableau* published during 1984. Graphics, photography, and scientific editing combined their efforts to maintain and improve the high quality of production of publications and support material necessary for the transfer of knowledge and technology to the scientific community and the agri-food sector.

Further information can be obtained from the Director, Research Program Service, Research Branch, Agriculture Canada, Ottawa, Ont. K1A 0C6.

Yves Bélanger
Acting Director

AWARDS AND BRANCH LIAISON

Research Program Service continued to administer the operating grants, visiting fellowships, and scientific exchange programs during 1984. Operating grants are awarded to individual researchers at Canadian universities as contributions toward the costs of proposed research projects that will be of value to the agricultural industry. The selection committee is made up of three representatives from Agriculture Canada and seven from faculties of agriculture and veterinary science. In 1984, the committee received 320 applications.

The visiting fellowship program gives promising young scientists, from all over the world, the opportunity to work with distinguished researchers in their respective fields before embarking on careers in scientific research. The program is administered by the Natural Sciences and Engineering Research Council on behalf of Canadian government departments and agencies. Research Program Service acts as liaison between the council and Agriculture Canada. In 1984, there were 286 applications for fellowships in this department.

The branch liaison unit arranged for 57 scientists to visit branch establishments during the past year: ten missions from France; three missions from the People's Republic of China; two missions each from Cuba, the Federal Republic of Germany, Japan, and the USSR; and one mission each from Australia, Belgium, Czechoslovakia, Egypt, Hungary, Indonesia, Israel, the Ivory Coast, Madagascar, Mexico, Peru, Portugal, and Senegal. The unit also made arrangements for 15 scientists to visit France, three to the Federal Republic of Germany, and one to the United Kingdom.

GRAPHICS

A wide variety of services in research photography, art production, and illustrations were provided to the branch and other agencies within the department. A total of 2287 jobs were handled, generating 52 867 pieces of work, representing an increase of 16% over the previous year.

The demand for services from the photography unit had an overall increase of 5% over last year. The areas where the most significant increases took place were in black-and-white contact prints and color slides with 30% and 110%, respectively.

The addition of an automated color film processor has enabled the Photography Unit to double the production of color enlargements used for exhibition purposes by the Research Branch across Canada. It has also, along with other technology improvements made in previous years, permitted the unit to lower its turnaround time to

6 days when only photographic work was required.

Forty-five seminar displays were produced by the art and design unit, including five large panels for the program for energy research and development in agriculture and food (ERDAF), requested by the Engineering and Statistical Research Institute. The overall turnaround time for jobs requiring graphics work only was reduced to 8 days.

SCIENTIFIC EDITING

A total of 35 departmental and 103 Research Branch publications were released during the year. Of these, four were priced publications. Some of the publications issued were *Alfalfa leafcutter bee management in Western Canada/L'élevage de la découpeuse de la luzerne (mégachile) dans l'ouest du Canada*; *Bean diseases and their control/Maladies des haricots et moyens de lutte*; *Compendium of licensed varieties—potatoes/Compendium de variétés homologuées—pommes de terre*; *Agriculture Canada recipients of merit awards for outstanding contributions to agriculture/Prime au mérite accordée aux employés d'Agriculture Canada pour leur contribution exceptionelle en agriculture*; *The insects and arachnids of Canada. Part 12. The families and subfamilies of Canadian chalcid wasps*; *Cultivating red raspberries in Eastern Canada/La culture du framboisier rouge dans l'est du Canada*; *Smut diseases of wheat, barley, oats, and rye/Les charbons du blé, de l'orge, de l'avoine et du seigle*; *Recommended code of practice for care and handling of pigs/Règles de conduites recommandées pour l'entretien et la manutention des porcs*; *Herbaceous perennials for the Prairie Provinces/Herbacées vivaces pour les provinces des Prairies*; *Pesticide research report*; long histories for the research stations at Charlottetown, Delhi, and Lacombe and short history folders for Harrow and Kamloops; nine issues of *Tableau*; and four issues of the *Pesticide Information/Information pesticides* newsletter.

Twenty bulletins were published in the Research Branch technical bulletin series, which provides timely technology transfer to specialized audiences.

SCIENTIFIC INFORMATION RETRIEVAL

The inventory of Canadian agricultural research (ICAR) and the Research Branch project outline system were updated in 1984. Access to both these systems continues to be provided across Canada to the whole research community and to Research Branch personnel.

All six components of the pesticide research information system (PRIS) became fully operational in 1984, all in various stages of completion. This completes development of phase IV. International access to the data base has been tested and has proven both highly feasible and desirable.

Expertise of the service and the world leadership role in data base development has been exemplified by visits from Chinese, French, and English delegations.

Forty-nine sheets of a branch *Compendium of licensed varieties/Compendium de variétés homologuées* are now available for potatoes. The sheets were prepared in nine languages in cooperation with the Food Production and Inspection and the Marketing and Economics branches.

The biocontrol unit continued to provide a service in the importation of parasites and predators for the Research Branch and the Canadian Forestry Service. In 1984, 14 shipments were received from eight countries; these consisted of 250 000 individual specimens of parasites and predators. Four agricultural and three forestry projects were involved. Sixteen shipments were sent from Ottawa for liberation of laboratory studies in six provinces. There were 11 parasite and predator species involved and a total of 2069 individuals.

Atlantic Region
Région de l'Atlantique

E.E. Lister

W.B. Collins

S.C. Cassidy

Director General *Directeur général*	E.E. Lister, BSc, MSc, PhD
Program Specialist *Spécialiste en programmes*	W.B. Collins, BSc(Agr), MSc, PhD
Acting Chief, Administrative Services *Chef intérimaire des Services d'administration*	S.C. Cassidy

PREFACE

The Atlantic Region, with headquarters in Halifax, consists of four research stations, two experimental farms, and two substations. These research establishments serve the agricultural communities in New Brunswick, Prince Edward Island, Nova Scotia, and Newfoundland. In addition, the regional establishments make major contributions to national programs on potatoes, food processing, livestock feeds and nutrition, postharvest storage and control of insects, diseases, and weeds. In 1984, the region managed a budget of $23 million and employed 100 professionals to carry out its programs.

The soil management program emphasizes the development of practical management technologies to cope with problems of erosion and physical constraints related to impermeable subsoils and with problems in developing the potential of peatland resources in the region. The soil resources of the New Brunswick research establishments were characterized during the year, to provide a base for the extrapolation of research results. Advances in drainage technology for peat soils are also reported.

The livestock and livestock feeds research program is directed toward developing improved feeding and management systems using locally produced feedstuffs, for beef and dairy cattle, swine, and poultry. Nutritional studies in relation to growth and development of broiler chickens, sheep, Holstein steers, and dairy cattle and calves are among the items discussed. Research studies on swine management for induction of early puberty and on changes in the profiles of epithelial enzymes in the rumen of developing calves are also promising.

The objectives of the cereal research program are to develop superior cultivars for the region, to develop improved crop-management systems, and to elucidate the factors mediating hardiness in winter cereals. Highlighted results include reports on the breeding and evaluation of spring wheat, spring and winter triticale, and oats; on management factors affecting floret fertility in winter wheat; on the effects of growth regulators and fertility on crop management; and on factors affecting the development and distribution of *Pyrenophora* and *Fusarium* diseases.

The forage crops research program aims to develop improved forage management practices and methods of storage and utilization. Progress in forage management and nutrition in red clover breeding and in the management of forages on peatland soils is discussed.

The objectives of horticultural crops research are to improve crop production, with emphasis on the potato, through approaches in breeding, management, protection, nutrition, and physiology. Progress in potato research is reported on breeding methodology, on improved disease diagnosis, on advances in control of insect and disease, and on the development of superior crop-management systems. Progress is also presented, in several fruit, vegetable, and ornamental crops, on new cultivar development, crop-management refinements, and improved pest-management strategies, with emphasis on biological control and integrated pest management.

Research in processing technology and storage aims to improve the competitive advantage of regionally produced products in the marketplace. Progress is detailed on improvements in processing technology for berry crops and on advances in storage technology for fruits and vegetables.

Significant staff changes in 1984 included the appointment of Dr. Y. Martel as Director of the Fredericton Research Station, succeeding Dr. C. Bernard who transferred to the Regional Development Branch, and the retirement of Mr. Robert Chancey as Director of the St. John's West Research Station. Dr. H R. Davidson was appointed as the new Director at St. John's West and Mrs. Susan Bowes resigned as Chief of Administrative Services for the Atlantic Region Headquarters.

Further information about our programs may be obtained by writing to the research establishment concerned or by addressing inquiries to Atlantic Region Headquarters, Research Branch, Agriculture Canada, 1888 Brunswick Street, Halifax, N.S. B3J 3J8.

E.E. Lister
Director General

PRÉFACE

La région de l'Atlantique, dont l'administration centrale est à Halifax, comprend quatre stations de recherches, deux fermes expérimentales et deux stations satellites. Ces établissements de recherches dispensent des services aux collectivités agricoles du Nouveau-Brunswick, de l'Île-du-Prince-Édouard, de la Nouvelle-Écosse et de Terre-Neuve. En outre, les établissements régionaux jouent un rôle important dans les programmes nationaux sur la pomme de terre, la transformation des aliments, l'alimentation du bétail, l'entreposage des récoltes et la lutte contre les insectes, les maladies et les mauvaises herbes. En 1984, la région a administré un budget de 23 millions de dollars et employé 100 professionnels pour mener à bien ses divers programmes.

Le programme de gestion des sols est axé sur la mise au point de techniques pratiques permettant de lutter contre l'érosion et de surmonter les contraintes physiques posées par les sous-sols imperméables ainsi que les problèmes de développement du potentiel des tourbières de la région. On a caractérisé les ressources en sol des établissements de recherches du Nouveau-Brunswick, au cours de l'année, car ces données peuvent servir à extrapoler les résultats de recherches. Les chercheurs ont également amélioré les techniques de drainage des sols tourbeux.

Le programme de recherches sur le bétail et son alimentation a pour objet d'améliorer les systèmes d'alimentation et de conduite d'élevage en utilisant de la nourriture produite localement pour les bovins de boucherie, et les bovins laitiers, les porcs et la volaille. Il est notamment question d'études visant à établir des relations entre, d'une part, la nutrition et d'autre part, la croissance et le développement ds poulets à griller, des moutons, des bouvillons ainsi que des bovins laitiers et des veaux. Les recherches sur l'induction précoce de la puberté chez le porc et sur les modifications des profils des enzymes de l'épithélium du rumen des veaux en croissance semblent également prometteuses.

Le programme de recherches sur les céréales a pour objet de mettre au point des cultivars supérieurs adaptés à la région, d'améliorer les systèmes de conduite des cultures et de préciser les facteurs qui conditionnent la rusticité des céréales d'hiver. Voici quelques-uns des résultats mis en lumière: rapports relatifs à l'obtention et à l'évaluation du blé de printemps, du triticale de printemps et d'hiver, ainsi que de l'avoine; aux facteurs d'exploitation qui influent sur la fertilité des fleurs du blé d'hiver; aux effets des régulateurs de croissance et de la fertilité sur la conduite des cultures; et aux facteurs influant sur l'apparition et la distribution des maladies qui affectent *Pyrenophora* et à *Fusarium*.

Le programme de recherches sur les cultures fourragères vise à améliorer les pratiques d'exploitation, les méthodes d'entreposage et l'utilisation. Il est question des progrès dans les domaines de la conduite et de la fertilisation des cultures fourragères, de l'amélioration du trèfle rouge et de l'exploitation des cultures fourragères sur les sols tourbeux.

L'objectif des recherches portant sur les cultures horticoles est d'accroître la productivité de diverses cultures, notamment celle de la pomme de terre, en étudiant divers aspects, soit l'amélioration de la plante, la conduite, la protection et la fertilisation de la culture, ainsi que la physiologie de la plante. Les recherches sur la pomme de terre ont permis de réaliser des progrès dans les domaines de l'amélioration de la culture, du diagnostic des maladies, de la lutte contre les insectes et les maladies et de la mise au point de systèmes de conduite des cultures. Des études portant sur plusieurs fruits, légumes et cultures ornementales ont permis de sélectionner de nouveaux cultivars, de perfectionner les systèmes de conduite des cultures et d'améliorer les stratégies de lutte antiparasitaire, surtout la lutte biologique et la lutte intégrée.

Les recherches axées sur les techniques de transformation et sur l'entreposage visent à améliorer la position concurrentielle des produits de provenance régionale sur le marché. On expose en détail les trouvailles dans le domaine de la transformation des petits fruits et les progrès dans le domaine des techniques d'entreposage des fruits et des légumes.

En 1984, il y a eu d'importants changements dans la composition du personnel, dont la nomination d'Yvon Martel comme directeur de la station de recherches de Frédéricton. Il a succédé à C. Bernard, qui a été muté à la Direction générale du développement régional. Robert Chancey, directeur de la station de recherches de St-John's West, a pris sa retraite et a été remplacé par H.R. Davidson. Enfin, Susan Bowes a démissionné de son poste de chef des services administratifs de l'administration centrale de la région de l'Atlantique.

Pour de plus amples renseignements sur nos programmes, veuillez écrire à un établissement de recherches de la région ou vous adresser à l'administration centrale de la région de l'Atlantique, Direction générale de la recherche, Agriculture Canada, 1888, rue Brunswick, Halifax (N.-É.), B3J 3J8.

E.E. Lister
Directeur général

Research Station, St. John's West, Newfoundland

PROFESSIONAL STAFF

H.R. Davidson,[1] BSc, PhD, PAg	Director
Horticulture	
B.G. Penney, BSc, MSc	Vegetable crops
Plant Breeding and Pathology	
K.G. Proudfoot, BAgr, MAgr	Program leader; Potato breeding
M.C. Hampson, BSc, MSc, PhD	Plant diseases
Agronomy	
A.F. Rayment, BSc, MSc	Program leader; Soil fertility and drainage
Departures	
H.W.R. Chancey, BSA, MSA, FAIC Retired 3 August 1984	Director
R.F. Morris, BSA, MSc, FESC Retired 28 December 1984	Program Leader; Entomology

[1]New appointment effective 6 August 1984.

INTRODUCTION

The research station located at St. John's West, 8 km from the city center, is responsible for agricultural research in Newfoundland and Labrador. Two additional research facilities are operated: a peat research substation at Colinet, 80 km southwest of St. John's, and a blueberry research substation near Avondale, 67 km west of St. John's. Research programs include the development of drainage techniques for peat soils and the designing and adaptation of equipment for cultivating, fertilizing, seeding, and harvesting peat soil crops. Potato breeding for resistance to wart disease and golden nematode, rutabaga breeding for resistance to clubroot disease, economic insect control, and vegetable nutrition and adaptation trials are also important research areas.

This report provides brief summaries of some of the results obtained in 1984. Further information, reprints of listed publications, and copies of previous reports can be obtained from the Research Station, Research Branch, Agriculture Canada, P.O. Box 7098, St. John's West, Nfld. A1E 3Y3.

H.R. Davidson
Director

ENTOMOLOGY

Cabbage maggot

Rutabagas. Field tests for tolerance of cabbage maggot, *Delia radicum* (L.), to fensulfothion (Dasanit), chlorofenvinphos (Birlane), and carbofuran (Furadan) were continued at St. John's and Wooddale. Fensulfothion (Dasanit), both as single and split applications, was completely ineffective at both locations; carbofuran (Furadan) was effective at St. John's but less so at Wooddale; and chlorofenvinphos (Birlane) was effective at Wooddale but ineffective at St. John's.

Cabbage maggot pupae collected at St. John's and Wooddale were screened for resistance to fensulfothion, carbofuran, and diazinon as adult fly populations by the London Soil Pesticide Laboratory. The St. John's strain displayed a similar susceptibility to fensulfothion, diazinon, and carbofuran as a susceptible strain from London. The Wooddale strain was slightly more tolerant of fensulfothion, but because the strain was from field-collected pupae, the difference was not considered significant. Carbofuran was considerably less toxic to the Wooddale strain and may indicate development of a low level of resistance to this insecticide. Since both strains of cabbage maggot flies were not resistant to organophosphate and carbamate insecticides, results from both locations support the theory that the widely used insecticide fensulfothion and carbofuran are biodegraded by soil microorganisms—carbofuran to a lesser extent at St. John's. Additional insecticides evaluated for maggot control included turbofos (Counter) and isofenphos (Amaze). The most effective insecticides, in terms of percentage of control, at St. John's were turbofos (75.4%), isofenphos (71.1%), and carbofuran (71.0%); at Wooddale, chlorofenvinphos (89.7%), isofenphos (81.1%), and turbofos (72.4%) were most effective.

Late cabbage. Nine insecticides, including cypermethrin (Ripcord and cymbush), cyfluthrin (BAY FCR 1272), and carbaryl (Sevin), were tested at St. John's for control of imported cabbageworm, purple-backed cabbageworm, and diamondback moth on cabbage. In a heavy infestation of imported cabbageworm, three applications of cyfluthrin gave complete control and were more effective than double and single applications. Double applications of cypermethrin, carbaryl, and cyfluthrin were more effective than single applications, which provided inadequate control. Yields of marketable cabbage were significantly higher where double and triple applications of insecticides were used.

Blueberry leaf tier. In cooperation with Dr. W. Seabrook of the University of New Brunswick, studies were initiated at Pouch Cove to determine the most effective nonsaturating trap type for leaf tier and to develop a control method in which mating is suppressed by permeating the air with an attractant. Preliminary studies indicate that a closed-pail-type trap with holes, baited with a low concentration of E/2 11-14 pheromone, plus vapona, plus a water-and-oil surface catcher, captured the greater number of moths. Impregnated Hercon chips scattered over an area of 48 m^2 to suppress mating by permeating the air with attractant suppressed mating by 55%, indicating that male moths were unable to orient themselves toward calling females.

European earwig parasites. During late summer and fall, 266 tachinid parasite pupae, *Bigonicheta setipennis* (Fallen), were collected at St. John's and forwarded to the Biological Control

Unit, Research Program Service, Research Branch, Ottawa. The Biological Control Unit plans to introduce the parasite in Halifax, N.S., and in certain areas of Ottawa where the European earwig has recently established itself as an important pest in vegetable gardens and in homes. The parasite was introduced into Newfoundland from British Columbia in 1951–1953 and Switzerland in 1959–1963.

HORTICULTURE

Peat soil

Carrot. An investigation into the effect of N source on carrots showed no significant differences in marketable or total yield, mean carrot length, or plant stand among diammonium phosphate, ammonium nitrate, and calcium nitrate. However, N rate did affect production. An application of N at 150 kg/ha significantly increased marketable and total yields, but when N was increased to 300 kg/ha yields were reduced. Plant stand was significantly reduced when N was increased from 150 to 300 kg/ha, which probably accounted for the lower yield at the higher rate.

Mineral soil

Rutabaga. In 1984, a preliminary trial was established to determine the effect of source and rate of N on storage rot in rutabaga. Marketable and total yield were significantly higher, and the percentage of diseased rutabaga at harvest time was significantly lower with ammonium nitrate or calcium nitrate than with diammonium phosphate. However, there was no significant difference in yield or in the percentage of diseased rutabaga between plots treated with calcium nitrate and those treated with ammonium nitrate. Marketable and total yields were significantly higher and the percentage of diseased rutabaga significantly lower at an N rate of 200 than at 100 kg/ha.

Lowbush blueberry. Yield data were obtained in 1984 from a weed control trial established in May 1983, to evaluate factorial combinations of three rates each of hexazinone (active ingredient (a.i.) at 0, 1, 2 kg/ha) and atrazine (a.i. at 0, 4, 8 kg/ha). Both herbicides increased yield, but ripe fruit yields were higher in plots treated with hexazinone. Compared with the untreated plot, hexazinone increased ripe fruit yields 91 and 153% at the rates of 1 and 2 kg/ha, respectively. Atrazine, on the other hand, increased yields 38 and 72% at the rates of 4 and 8 kg/ha, respectively. Herbicide combinations did not give better results than either product applied alone.

In 1983, research was initiated to determine whether stands and yield of native lowbush blueberry could be improved with fertilizer used in conjunction with a weed control program. Blueberry stem samples taken in November 1984 showed that stem density and total flower buds were increased 19 and 47%, respectively, with an application of N at 60 kg/ha. No response was observed to applications of P at 26.2 kg/ha or K at 49.8 kg/ha. Stem density and total flower buds were increased 51 and 151%, respectively, in plots where a chemical weed control program was used.

SOIL SCIENCE

Peat soils

Drainage. An experiment designed to evaluate supplemental slit drains and various drain liners has provided evidence that peat deposits have a significant effect on the hydrology of an area. During the dry period of July and early August, less than half the water flowed from drains with the supplemental drainage treatment compared with those without, whereas during normal wet weather the opposite was true. This is viewed as a function of run-off control, and though the differences were small in the context of this experiment, when extrapolated to the contrast between a virgin peat bog and an open pond of water, the differences would be expected to be much more substantial. Corrugated pipe liners, both fiber-wrapped and sawdust-embedded, appear somewhat better than the Norwegian type slab liners in lowering water tables and in total water efflux, and the fiber-wrapped pipe in particular appears to be causing changes in the drainability of the peat. Yields from timothy were not significantly affected by drainage treatments, and though incipient drought conditions were indicated by moisture tensiometers for a short period, yield responses favored the better drained areas.

Fertility. The first year of a study of timothy growth response curves to K on a mature peat soil was completed. Potassium was of most benefit in combination with the highest levels of P (80 kg/ha of the oxide) and N (150 kg/ha). The data show that the growth response curves fit a Mitscherlich equation having a C value of 0.0065.

Potato wart disease

Pathogenesis. Long, etiolated potato sprouts continued to be used as the primary assay material for influence of microenvironments on potato infection by *Synchytrium endobioticum* (Schilb.) Perc., the causal agent of wart disease of

potatoes. Immersion of the sprouts in suspensions of wart tissue or in the fungus itself was found satisfactory at 10–20°C for 4 h or more. A large number of chemical adjuvants were tested at various concentrations and pH values. It was confirmed that best infection occurs at about pH 5.4 ± 3. Best concentration of sodium chloride was 0.025 *M*. Concentration effect was very prominent using other chemicals.

Germination. In vitro cultivars of *Synchytrium endobioticum* yielded much useful information on germination characteristics. The spore was found to produce a vesicle within which a sporangium was differentiated. The vesicle is released through a pore in the resting spore wall. The sporangium is released through an eroded area of the vesicle to release zoospores through a pair of small pores. A television camera was mounted on the microscope to allow events to be recorded on a video cassette recorder. It was also found that vesicle formation is most active after soaking spores in water for about 10 days. The addition of glucose to the culture enhanced vesicle production.

Viability. Lipid analysis of resting spore contents and walls revealed large levels of lipids as glycerides and waxes, respectively. The wall contained branched chain lipids of unusual occurrence. Attempts were made to link these findings with viability and longevity of the fungus. Further work with nuclear magnetic resonance showed the feasibility of detecting chemical entities in resting spores.

Biological control. A parasite of *S. endobioticum* was found in many cultures of the fungus, and tentatively identified as a *Spizellomyces* sp. Work was initiated to identify an amendment sequence that will reduce levels of infection in soils and that will lead the way to a soil-cleansing technique. Urea has been identified as a promising chemical candidate for this sequence.

POTATO BREEDING

Dry weather during early stages of tuber initiation resulted in greater development of common scab on potato tubers during 1984 than in previous years. Severe scab was reported on one field of Brigus, but others remained substantially free of the disease. Mirton Pearl appears to have above average resistance to scab, but N664-127, a selection resistant to wart and golden nematode, has below average resistance. However, yields and cooking quality of this selection were again highly satisfactory, and further seed increase and grower acceptance trials are continuing. Thirty-three cultivars and advanced selections included in the NE107 trials were screened for both wart and golden nematode at Avondale. Four cultivars—Sunrise, Islander, Hampton, and Chipbelle—remained free of infection by both organisms and will be retested in 1985. Of 90 F81 selections from the national potato breeding program also tested at Avondale, 33 showed traces or zero infections of wart disease. Five selections out of nine from crosses of parents resistant to golden nematode were resistant to nematode but were susceptible to wart disease.

Five selections included in replicated yield trials have remained resistant to both wart and golden nematode after several years of tests. Of three blue-skinned selections, the yield and specific gravity of only one, N1051-1, was satisfactory. None of the white-skinned selections included in the test significantly outyielded Mirton Pearl or had a higher specific gravity. Yield of the red-skinned selection N961-9 was disappointing. The low yields were probably a result of delayed planting, caused by wet spring weather, which was followed by below-average rainfall during the summer.

RUTABAGA BREEDING

Plants from three generations of a program for selecting roots with reduced damage from root maggot attack were compared with resistant cultivars, Vige and Chignecto, and a highly susceptible line, 3-80. Differences between generations were small, but damage was much less than in the susceptible control. Vige was more highly resistant to injury than either Chignecto or the selected lines. Seedlings were raised from crosses of Vige with the clubroot resistant selection RST and were transplanted to the field. At harvest, roots with the least damage from root maggot attack were retained for seed production.

Crosses were made between RST and the cultivars Scotia and American Purple Top. Transplanted seedlings from these crosses were grown to maturity and evaluated for root maggot injury, color, and shape. Scotia cross plants were much superior to those of American Purple Top. As part of a cooperative program with the University of Guelph, seed was produced from crosses of a herbicide-resistant Laurentian breeding line and RST. Seedlings from this cross were grown in the field, and roots were free from clubroot but were susceptible to growth cracks. Roots have been retained for seed production, and seedlings will

be screened for herbicide tolerance and clubroot resistance.

Germination of seed and development of seedlings at 5°C has been investigated. A successful crop of roots was obtained from these seedlings and transplanted into the field, and selections have been retained for seed production.

Evaluation of RST was continued by commercial growers, and excellent crops of well-shaped roots free of clubroot were obtained. Multiplication of seed to establish basic seed stocks of this selection prior to release as a named cultivar is in progress.

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Research Station, Charlottetown, Prince Edward Island

PROFESSIONAL STAFF

L.B. MacLeod, BSc(Agr), MSc, PhD, FCSSS	Director
C.B. Willis,[1] BSc(Agr), PhD	Assistant Director
B. Stanfield,[2] BSA, MSA, MLS	Librarian
M.B. Bourdon, DJourn	Information Officer

Cereals

J.A. MacLeod, BSc(Agr), MSc, PhD	Head of Section; Forage and cereal nutrition
A.J. Campbell, BEng, MPhil	Agricultural engineering
M.R. Carter, BSc(Agr), MSc, PhD	Soil tillage
L.M. Edwards, BSc, MSc, PhD	Soil management
U.C. Gupta, BSc(Agr), MSc(Agr), PhD, FCSSS, FASA, FSSSA	Soil and plant micronutrients
H.W. Johnston, BSc(Agr), MSc, PhD	Cereal diseases
H.G. Nass, BSA, MSc, PhD	Wheat breeding, cereal physiology
J.D.E. Sterling, BSA, MSc	Barley breeding

Forage and Livestock

L.S. Thompson,[3] BSc(Agr), PhD	Head of Section; Forage, cereal, and potato insects
R.G. Andrew, BSc(Agr)	Agricultural economics
T.M. Choo, BSc, PhD	Red clover breeding
H.T. Kunelius,[4] BSc, MSc, PhD	Forage physiology and management
P.R. Narasimhalu, BSc, BVSc, MS, PhD	Forage quality and utilization
M. Suzuki, BSc, PhD	Forage and cereal biochemistry and physiology
C.B. Willis,[1] BSc(Agr), PhD	Forage diseases
K.A. Winter, BSc(Agr), MSc, PhD	Cattle nutrition

Horticulture and Tobacco

J.A. Cutcliffe, BSc(Agr), MSc	Head of Section; Vegetable nutrition and management
W.J. Arsenault, BSc(Agr)	Tobacco management and nutrition
J.A. Ivany, BSc(Agr), MS, PhD	Vegetable, potato, and cereal weed control
J. Kimpinski, BSA, MSc, PhD	Nematology
J.G. McDonald, BSc(Agr), MSc, PhD	Potato virus diseases
H.W. Platt, BSc, PhD	Potato diseases

D.C. Read, BSc(Agr), MSc, PhD	Pesticide bioactivity, vegetable insects
J.B. Sanderson, BSc(Agr), MSc	Potato management and nutrition
J.G. Stewart,[5] BSc, MSc	Entomologist in training
R.P. White, BS(Ed), MS, PhD	Corn and potato nutrition and management, soil chemistry

Departures

J.R. Enman, BSc(Agr) Transferred to Regional Development Branch, December 1984	Productivity enhancement program, Biologist
D.A. Hutchinson Retired November 1984	Administration Officer

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[1]Seconded to Program Coordination Directorate, Research Branch Headquarters, Ottawa, September 1984.
[2]Seconded from Libraries Division, Finance and Administration Branch.
[3]Acting Assistant Director, July 1984 to January 1985.
[4]Acting Head of Section, Forage and livestock, July 1984 to January 1985.
[5]On educational leave.

INTRODUCTION

The research station at Charlottetown has Atlantic region responsibility for research on the production and utilization of livestock feed crops (forages, cereals, protein), tobacco, and certain vegetable crops (cole, peas) grown for processing. Emphasis on potato research is in the areas of nutrition and management for processing and table potatoes, but especially for small whole-seed potato production. Research is also conducted on disease evaluation and control, and on postharvest testing by enzyme-linked immunosorbent assay (ELISA) for virus content of potatoes destined for the domestic and export seed markets.

In September, Dr. Carl Willis, Assistant Director, was seconded to the Program Coordination Directorate, Research Branch Headquarters, in Ottawa, for a 1-year period. In December, Allan Campbell, Research Engineer, completed his M.Phil. in Agricultural Engineering at Massey University, Palmerston North, New Zealand. Dr. Michio Suzuki is on a 7-month transfer of work at the Welsh Plant Breeding Station, Aberystwyth, Wales.

During the year the research station celebrated its 75th anniversary and published a history entitled *Charlottetown Research Station 1909–1984*. In addition, a new research area at Harrington, known as the Harrington Farm, was occupied. This property will accommodate most of the field plot research previously conducted on rented land. Finally, a potato storage research building for conducting tests on potato quality, storage, and disease evaluations was completed.

This report includes brief summaries of some of the research completed in 1984. More detailed information may be obtained by referring to the station's research summary, which is published annually, or by contacting the Research Station, Research Branch, Agriculture Canada, P.O. Box 1210, Charlottetown, P.E.I. C1A 7M8.

L.B. MacLeod
Director

CEREAL CROPS

Breeding and testing

Spring wheat and spring triticale. A license will be requested for the sale of seed of the Charlottetown spring wheat line AW62, which has been the highest yielding spring wheat for 3 yr in trials in the Maritime Provinces. It matures 1–2 days earlier than recommended varieties such as Milton and is affected less by major diseases such as head blight and *Septoria*. A license will be requested for the spring triticale Triticale 3, an introduction from Mexico. Triticale 3 has exceeded all spring wheat varieties in yield for 3 yr in trials in the Maritime Provinces, and is the first spring triticale suitable for production in the Maritimes.

Winter triticale. Laski, a Polish introduction, exceeded the recommended variety Decade in yield at most locations in the Maritime Provinces in 1984. It has a better test weight and kernel weight than Decade. Two new winter triticale lines, GWT 5 and GWT 8, developed at Guelph University have shown yield potential in eastern Canadian trials, showing superior winterhardiness compared with Decade or Lasko.

Oats. The Sainte-Foy Research Station will request a license for Q.O. 186.10, which has given yields equal to or better than recommended varieties, is earlier maturing, and has shown good groat yield and straw strength in 3 yr of trials in the Maritime Provinces. Q.O. 191.70 is another Sainte-Foy line with the highest yields in trials in the Maritime Provinces for the last 3 yr. It will probably be recommended for licensing next year. A license will be requested by the Ottawa Research Station for the hull-less oat OA 501-1, which is a considerable improvement over Terra and has shown superior yield, high test weight, and good straw strength in 3 yr of trials in the Maritime Provinces.

Identifying resistance to Septoria nodorum in spring wheat. Yield loss in spring wheat was not necessarily related to the level of symptoms of *S. nodorum*. Development of symptoms of *Septoria* leaf blotch, yield, and thousand kernel weight were good indicators of resistance to *S. nodorum* in field trials. Leaf blotch assessment was a better criterion than glume blotch in identifying resistant wheats. Although inoculations of floating leaf sections and young plants under controlled conditions identified resistant cultivars, several cultivars responded differently than they did in field trials. Artificial screening tests for *S. nodorum* are useful in identifying resistant cultivars but cannot entirely replace field tests.

Management and nutrition

Barley varieties under integrated cereal management (ICM). The use of growth regulators (Cerone), fungicide (Tilt), and high N levels caused a dramatically different response under the drought conditions of 1984 compared with 1983, when drought was not a factor. This was most noticeable with two-rowed varieties in general and with the variety Birka in particular. Under ICM in 1983 Birka improved its yield by 519 kg/ha, whereas in 1984 its yields were reduced by 1178 kg/ha. In the same study the yields of the variety Micmac benefited by 714 kg/ha and 414 kg/ha, respectively.

Micronutrient status of cereals and forages grown in P.E.I.. With the exception of a few forages, which might be considered low to deficient in S, Mo, and Cu, most others would be sufficient in Zn, Mn, and B in terms of plant nutrition. In general the content of B, Mo, and Cu in wheat, barley, and oats was found to be in the optimum range. A small percentage of cereal samples would be classed as low or borderline in Zn, Mo, and S.

Crop sequence studies. Yield performance of barley following soybeans was better than barley following barley. Yield advantage following soybeans was maintained even when a fungicide progam was used for disease control and at high levels of N application.

Winter cover crops. Shoot and dry weight (DW) of rapeseed in the late autumn and early spring was far inferior to that of rye. In general, later planting gave progressively lower fall-establishment DW and spring-recovery DW. All rye treatments survived the winter, whereas only the earliest planting of rapeseed survived. Jet Neuf was the best variety of rapeseed and Horton and Kodiak rye performed similarly. Sweetclover performed too poorly to be measured, having completely failed to survive the winter.

Winter rye response to autumn-placed potassium. The effect of autumn-placed K on ground cover dry weight performance of winter rye was assessed during the cool season. There was no treatment effect resulting from K on root or shoot dry weight measured in late autumn and early spring. There was also no effect on content of K in the tissues. There were significant varietal differences.

Diseases

Influence of nitrogen top dressing on intensity of net blotch on barley. A top dressing of 50 kg of N, as ammonium nitrate, at Zadoks Growth Stage 30, significantly reduced the intensity of net blotch on barley. Following treatment, disease intensity was reduced by 40 to 50% on Volla and Loyola barley at three seeding rates. In some tests the control was equivalent to that obtained from a regular fungicide spray program with chlorathanlonil.

Airborne distribution of Pyrenophora teres. The airborne distribution pattern of conidia of *P. teres* indicates that net blotch of barley arises mainly from inoculum sources within the field rather than from more distant sources. Collection of airborne conidia in and around a barley field indicated limited vertical or horizontal distribution of *P. teres*. More than 95% of total conidia trapped were below a 1-m height within the field. Of the total number of conidia collected, only 4.3% were trapped 10 m from the edge of the field.

Fusarium. Species of *Fusarium* pathogenic to cereals were recovered primarily from organic debris in the soil and in much higher numbers (14-fold) from organic debris in soils under cereals than from fallowed soil. *Fusarium* diseases were not reduced in severity by use of seed produced in areas of Canada noted for low frequency of occurrence of fusaria. Levels of crown infection were related to soil cropping history but head blight infections were unrelated to either crown infection or soil history. *F. graminearum*, *F. poae*, *F. avenaceum*, and *F. culmorum* were the most frequently recovered species from cereal heads. *Fusarium poae* was not commonly found in crowns, and *F. oxysporum* was the most frequently occurring *Fusarium* associated with crown tissue.

FORAGE AND LIVESTOCK

Red clover breeding

Characteristics of growth types. Plants of Hungaropoli red clover were classified into two types: nonflowering and flowering during the seedling year. It was found that in subsequent years, nonflowering plants were more persistent, grow more vigorously, and flowered earlier than flowering plants, and they had the same seed yield as flowering plants. These results confirmed that flowering response in the seedling year can be a useful selection criterion for persistent plants of red clover.

Anther culture of Trifolium species. Anthers from five genotypes of red clover, four of *Trifolium rubens*, and one of *T. diffusum* were cultured on an L2 medium. Plants were regene-

rated from two *T. rubens* genotypes, but no plants were regenerated from red clover and *T. diffusum*.

Forage management and nutrition

Timothy harvest systems reexamined. Clair, Champ, Itasca, and Bounty timothy representing very early, early, mid-season, and late cultivars, respectively, were cut at five dates and at primary growth stages ranging from vegetative to full heading. Regrowth was cut about 45 days after cut 1. Total dry matter yield and total N concentration for combined cuts 1 and 2 were generally influenced by cutting schedules but not by cultivars. The in vitro disappearance of dry matter (IVDDM) was dependent on cutting schedule, cultivar, and their interactive effects; the early maturing cultivar Clair reached its peak IVDDM earlier than the later maturing Champ, Itasca, or Bounty. At termination of the field study, there were fewer timothy tillers, and ground cover by timothy was slightly less for cuts during stem elongation. The currently recommended timothy cultivars in Atlantic Canada do not appear to provide sufficient range in maturity for the average growing season in certain parts of the region to warrant multiple cultivars on individual farms.

Composition, intake, and digestibility of wilted silages. Timothy and Italian Westerwolds annual ryegrasses were harvested as first-cut wilted silages during a 2-yr study. Chemical composition and sheep feeding trial to measure intake and digestibility were the basis of comparison for these silages. Timothy silage had more cell-wall content and was less digestible than the annual ryegrass silage in both years. Less seeding-year timothy was consumed than Westerwolds ryegrass. Postseeding-year timothy silage was equal in intake to Westerwolds ryegrass but inferior to Italian ryegrass in digestible-protein content and dry-matter intake. More of the leafier Italian ryegrass was consumed than the stemmy Westerwolds ryegrass. Prolonged field wilting in humid weather appeared to be more detrimental to the stemmy Westerwolds ryegrass for intake and feed value than to the leafier Italian ryegrass.

Livestock

Fish meal for steers. Both feeding fish meal, a poorly degradable protein, and implanting with estradiol-17-beta (Compudose) improved returns over input costs with Holstein steers. Holstein steers fed fish meal, at 250 g/day, as a supplement to a ryegrass silage–barley diet increased liveweight gains by 0.14 kg/day compared with steers fed a soybean meal supplement. The use of estradiol-17-beta as an implant increased rate of gain by 0.13 kg/day compared with nonimplanted steers.

HORTICULTURE AND TOBACCO

Vegetables and tobacco

Effect of boron and molybdenum on pea yields. Field experiments conducted at six locations over a 4-yr period in Prince Edward Island showed that yields of Rally peas were not affected by preplanting soil applications of B or Mo at rates of 2.0 and 0.25 kg/ha, respectively. Vine length, vine weight, and maturity were also not affected by the application of these micronutrients.

Copper on vegetable crops in Prince Edward Island. The addition of Cu at 2.0 and 4.0 kg/ha did not increase the yields of carrots, beets, onions, or rutabagas grown in soils normally used for these crops in Prince Edward Island. Copper concentrations in leaf tissue were in the range of 6–14 mg/kg and were generally not affected by the added Cu.

Effect of cover crop on raspberry yields. Early-season cultivation followed by oats seeded between the rows immediately after harvest each year produced a 3-yr mean yield of 7.9 t/ha. Plots cultivated throughout the season produced 7.5 t/ha and those where a grass sod was maintained to within 30 cm of the center of the row produced 5.8 t/ha.

Boron nutrition of cabbage and field beans. Boron application rates of 8 kg/ha reduced bean seed yields at all locations, and 4 kg/ha reduced yields at two in four locations. Boron applied at 8 kg/ha to a previous crop was not detrimental to a crop of beans in the following year. Rates of B up to 8 kg/ha were not toxic to cabbage, even during the year of application. Levels of B in leaf tissue that were greater than 109 mg/kg were clearly toxic for beans, but toxicity symptoms on the foliage were evident at a B level of 60 mg/kg. Concentrations of B in leaf tissue that were as high as 71–132 mg/kg were not related to a B toxicity in cabbage. Levels of B in tissue that were as low as 16 and 26 mg/kg in cabbage and beans, respectively, were not related to a B deficiency.

Soil pesticides. After applying subsurface band treatments to soil in two different fields for 2 consecutive yr with aldicarb and several organophosphorus soil insecticides, strains of microorganisms became adapted to rapidly breaking down aldicarb in soil from a field with a pH of 6.2 but not in a field with the more acidic soil (pH 5.6). Microorganisms did not become adapted to rapidly degrade fonofos, chlorfenvinphos, terbufos, or phorate in either field. In laboratory selection tests, applications of 100–750 mg/kg of aldicarb could be broken down by selected microorganisms in 1–3 wk, but con-

centrations of 1000–4000 mg/kg were toxic to the microorganisms. With respect to health hazards and concerns about long-term persistence of residues of 4–100 nL/L of aldicarb found in a contaminated groundwater laboratory, laboratory tests on microbe selection have produced strains of microorganisms that will break down amounts of 500 000 nL/L in water in less than a week.

Slug control. Tests confirmed that night sprays of methiocarb were highly effective in destroying slugs in crops such as Brussels sprouts as well as on lawns. Methomyl, oxamyl, aminocarb, and mexacarbate were also effective but higher rates were required than for methiocarb. Daytime sprays were ineffective, and baits were of questionable value.

Soil fumigants for Thielaviopsis basicola control in tobacco. A 3-yr study conducted at three locations showed that Telone C17, compared with Vapam and Vorlex CP, applied at 74 L/ha provided the best control of *T. basicola*. Telone C17 increased yield by 7% and dollar return per hectare by 8% in comparison with the nonfumigated treatment.

POTATO MANAGEMENT AND PEST CONTROL

Potato diseases. The use of metalaxyl, a systemic fungicide, alone and in combination with mancozeb (a protectant fungicide) to eradicate established infections of *Phytophthora infestans* (causal agent of potato late blight) was unsuccessful. Similarly, oxadixyl, another systemic fungicide, did not prevent continued development of disease when applied after levels of foliar disease had reached 15–25% defoliation. Spray programs for disease prevention provided a much better means of late blight control. In other studies on fungicide treatment of seed before storage and before planting, no significant differences in treatment were found as a result of unfavorable conditions for development of disease. However, thiophanate-methyl and imazalil were found to reduce plant stand, plant vigor, and yield because of a combination of poor disease control and phytotoxicity to planted seed.

Quack grass control in potatoes with sethoxydim. In greenhouse and field studies sethoxydim gave good control of quack grass in Russet Burbank potatoes. In the greenhouse, addition of oil surfactant Canplus 411F at 1.0% vol/vol improved quack grass control with sethoxydim as active ingredient (a.i.) at 0.6 kg/ha. Removal of treated quack grass shoots at 6 or 24 h after treatment resulted in decreased control at application rates of a.i. at 0.6, 1.0, and 1.6 kg/ha, indicating that more than 24 h was needed for complete translocation of sethoxydim to the rhizomes. In the field, application of sethoxydim as a.i. at 1.2 or 1.6 kg/ha gave excellent control when applied to quack grass at the 3- or 6-leaf stage. Cultivation 2 days after treatment did not adversely affect level of control obtained. Sethoxydim did not cause any adverse effect on potato yield, but delaying application until the quack grass was at the 6-leaf stage resulted in yield loss due to quack grass competition.

Potato flea beetles affect some tuber yields. Marketable yields of Russet Burbank and Superior potatoes were reduced in 1983 and 1984 when flea beetle populations were high, whereas Russet Burbank yields were not reduced in 1981 and 1982 when flea beetle populations were considered low. In another study in 1984, yields of Superior, Kennebec, Russet Burbank, and Red Pontiac were all reduced when high flea beetle populations were not controlled, whereas those of Sebago and Shepody were not reduced. Early-maturing varieties appear to be affected by flea beetles, but mid- to late-season varieties may not be significantly affected, depending upon the population of flea beetles present in the field.

Virus detection in the tuber after dormancy breaking. Treatment with bromoethane was as effective as rindite as a means of artificially breaking tuber (Russet Burbank) dormancy, but was less effective as a means of increasing the concentration of potato virus Y for postharvest testing of tubers by ELISA. The concentration of potato virus S in the tuber did not change in response to breaking tuber dormancy by either treatment.

Causes of mosaic in potato. Causes of mosaic disease in three potato cultivars were determined by correlating symptoms of the disease with the presence of mosaic-inducing viruses detected by ELISA. Potato viruses Y(PVY) and X(PVX) were associated with mosaic disease in all three cultivars, but to varying degrees; PVY was present in 89% of the samples of Shepody showing severe mosaic but only in 59% and 32%, respectively, of the samples of Red Pontiac and Green Mountain. Potato virus A(PVA), however, was only found in the Green Mountain cultivar.

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Research Station, Kentville, Nova Scotia

PROFESSIONAL STAFF

Administration

G.M. Weaver, BSc, PhD	Director
R.G. Ross, DFC, BSc(Agr), MSc, PhD	Assistant Director
G.P. Shortt	Administrative Officer

Scientific Support

K.B. McRae,[1] BEd, MS, PhD	Regional Statistician
J.R. Miner,[2] BA, MLS	Librarian
W.D. Regan,[3] BMath	Computer Systems Manager
H. Myer, BSc	Computer Systems Programmer

Agronomy

R.W. Jones, BSc, MSc, PhD	Head of Section; Cereal physiology and management

Berry Crops

I.V. Hall, BSc, MSc, PhD	Head of Section; Berry crops ecology and management
C.R. Blatt, BSc, MSc, PhD	Crop physiology and nutrition
A.R. Jamieson,[4] BSc, MSc	Berry crops breeder
N.L. Nickerson, BSc, MSc, PhD	Berry crops diseases

Crop Protection

R.G. Ross, DFC, BSc(Agr), MSc, PhD	Head of Section; Tree fruit diseases
M.G. Anderson, BSc, PhD	Vegetable storage and cereal diseases
S.O. Gaul,[4] BSc, MSc	Residue chemistry
J.M. Hardman, BSc, MSc, DIC, PhD	Insect ecology
P.D. Hildebrand, BSc, PhD	Berry crops and vegetable diseases
K.I.N. Jensen, BSc, MSc, PhD	Weed physiology
E.R. Kimball, BSc	Residue chemistry
C.L. Lockhart, BSc(Agr), MSc	Berry crops and vegetable diseases
W.T.A. Neilson, BSc, MSc	Fruit maggots
M.T.H. Ragab, BSc, MSc, PhD	Residue chemistry
K.H. Sanford, BSc(Agr), MSc	Integrated control of orchard insects
H.B. Specht, BSc(Agr), MSc, PhD	Field crops and vegetable insects

Ornamentals

P.R. Hicklenton, BSc, MSc, PhD	Head of Section; Ornamental and greenhouse crops physiology

Poultry

F.G. Proudfoot, BSc(Agr), MSc	Head of Section; Poultry physiology and management
H.W. Hulan, BSc(Agr), MSc, PhD	Poultry nutrition and physiology

Food Processing

R. Stark,[5] BSc, PhD	Head of Section; Food technology
J.M. Burrows, BSc(Ag Eng)	Food engineering
E.D. Jackson, BTech, MSc, PhD	Food microbiology
R.A. Lawrence, BSc(Chem Eng), MSc (Food Eng)	Food engineering

Fruit and Vegetable Storage

P.D. Lidster, BSc, MSc, PhD	Head of Section; Storage physiology
P.A. Poapst, BSc(Agr)	Storage physiology

Tree Fruits

A.D. Crowe, BSc(Agr), MSc, PhD	Head of Section; Tree fruit breeding and physiology
C.G. Embree, BSc(Agr), MSc	Tree fruit physiology and management
D.H. Webster, BSc, MSc, PhD	Soils and nutrition

Vegetables

C.L. Ricketson, BSc(Agr), MS, PhD	Head of Section; Vegetable physiology and management

Nappan Experimental Farm, Nappan, N.S.

F.W. Calder, BSc(Agr), MS	Superintendent; Forage crops and agronomy
L.F. Laflamme, BSc(Agr), MSc, PhD	Ruminant nutrition
J.E. Langille, BSc(Agr)	Agronomy, cereal and forage crops
R. Troelstra,[6] BSc(Agr)	Beef management and nutrition
T.A. Van Lunen, BSc(Agr)	Swine management and nutrition
N.R. Williams, BSc(Agr)	Sheep management and nutrition

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[1]Transfer of work—Rothamsted Experimental Station, England.
[2]Seconded from Libraries Division, Finance and Administration Branch.
[3]Seconded from Systems and Consulting Directorate, Finance and Administration Branch.
[4]Educational leave to University of Guelph.
[5]Transfer of work—Campden Food Preservation Research Association, England.
[6]Seconded from Regional Development Branch.

INTRODUCTION

The Kentville Research Station conducts a comprehensive research and development program, which is focused on the horticultural, poultry, and winter cereal sectors of the agricultural industry in Atlantic Canada. The research is multidisciplinary and encompasses genetic improvement, nutrition, and management as well as the protection of economic crops from insects, diseases, and weeds. Increasing emphasis is being placed on the research and development needs of the food processing industry through development of new products as well as improvements in process technology. Extension of the effective marketing season for domestic fruit and vegetable produce is also being stressed through innovative storage research.

The management of livestock and their related feed crop requirements are studied extensively at the Nappan Experimental Farm. Emphasis is on the beef cow–calf, sheep, and swine production systems, and the research program being conducted at this location has been significantly strengthened during the past year through increases in the professional staff.

The research results reported herein are intended to provide an overview of current studies and progress achieved. More complete information may be obtained in the annual research reports of the two establishments as well as by writing to the Research Station, Agriculture Canada, Kentville, N.S. B4N 1J5 or the Experimental Farm, Nappan, N.S. B0L 1C0.

G.M. Weaver
Director

BREEDING, NUTRITION, AND CULTURE OF CROPS

Cranberries

Ecology, physiology, and economic importance. An account of the large, or American, cranberry has been accepted for the series *The Biological Flora of Canada*. *Vaccinium macrocarpon* Ait. is an evergreen trailing dwarf shrub native to eastern North America. It occurs around the margins of lakes, on bogs, along the edges of stream banks, and along the seacoast, particularly in poorly drained areas behind sand dunes. In Canada, plants flower from the last week of June to the end of July, and the berries mature in late fall, usually during the last 2 wk of October. Named cultivars are grown commercially in the United States, particularly in New Jersey, Massachusetts, Wisconsin, Washington, and Oregon. In Canada the main commercial area is in British Columbia, with fewer plantings in Nova Scotia, Quebec, and Ontario. The attractive dark red berries are used in the production of sauce and jelly. Currently more than 50% of the crop goes into the production of cranberry juice.

New disease caused by Exobasidium. A previously unreported shoot disease, caused by a species of the fungus *Exobasidium*, was found on cranberries (*Vaccinium macrocarpon* and *V. oxycoccos*) in the Atlantic Provinces.

Diseased shoots had elongated internodes and bright red enlarged leaves, which eventually became covered beneath with the white fungal hymenium. The shoots arose in clusters from below ground or from axillary buds of vines covered with moss. After the fungus had sporulated, the shoots withered, but new diseased buds emerged each spring from stumps of the previous year's growth, indicating that the mycelium was perennial in the host. Although infected shoots did not flower, losses in fruit production were minor, since fewer than 1% of the shoots were diseased at each site examined. The fungus was described as *Exobasidium perenne* sp. nov. on the basis of morphological characters.

Lingonberries

Productivity of native stands. Production studies were conducted from 1980 to 1982 on natural strands of lingonberry (*Vaccinium vitis-idaea* L. var. *minus* Lodd) at Little Catalina, Newmans Cove, Adams Cove, Pouch Cove, and Riverhead, St. Mary's Bay in eastern Newfoundland. Production varied with location and year, with highest average total yields from Little Catalina (103 g/m^2), Pouch Cove (101 g/m^2), and Adams Cove (88 g/m^2). Yield increased with maturity, but decreased after most of the crop was ripe. Crop maturity was earliest at Pouch Cove, but there was little difference among the other sites. The average mature berry weight (23 and 30 September harvest dates) was greater at Adams Cove (0.39 g) than at the other locations that had similar berry weights (0.32 g).

Lowbush blueberries

Progeny selection. Eight seedling progenies were tested for yield and all had satisfactory per-

formance. Seedlings of the cross Chignecto × 895 had the highest mean yield (3900 kg/ha) during the 3-yr period 1982–1984.

Plant spacing and cultivars. Augusta, Chignecto, and 510 were harvested for the third consecutive season. A fourth cultivar, Brunswick, did not produce flowers or fruit in 1984. This year the yields in grams per plant did not increase significantly because of increasing plant density with any cultivar, but the 1984 yields of each cultivar were greater (33–148%) than their respective 1983 yields on a grams-per-plant basis. Mean yield per hectare over all clones was 10, 11, and 12.9 t for the single-, double-, and triple-row spacings, respectively.

Sawdust mulch and trickle irrigation. The clone Chignecto and the seedling Chignecto × 70-13 were harvested for the first time in a sawdust mulch–trickle irrigation experiment. The clone (Chignecto) outyielded the seedling by 42% over all treatments. The addition of sawdust increased yields by 50% (clone and seedling combined) compared with no sawdust. Irrigation had no effect on yields this season. Clone and seedling plots receiving sawdust and no irrigation produced marketable yields that were 92% (clone) and 71% (seedling) higher than those from plots having no sawdust or irrigation applied.

Fertilizer study. The clone Chignecto and seedlings Augusta × 451 and Chignecto × 70-13 received treatments that included a control and three rates and ratios of N, P2O5, and K2O. First crop results indicate that highest yields of marketable fruit from Chignecto were obtained with N at 50 kg/ha; this was 34% higher than the yield with N at 150 kg/ha and 24% higher than the yield from the control. Marketable yields from the seedlings receiving N at 100 kg/ha were 34% higher than seedlings receiving N at rates of 50 and 150 kg/ha and 18% higher than the control. For the seedlings, the fertilizer 21-7-14 (N-P2O5-K2O) recorded an average (all rates combined) yield increase of 31% compared with the fertilizer ratios of 19-19-19 and 12-24-24.

Strawberries

A comparison of micropropagated and conventionally propagated strawberry cultivars. Field plots of micropropagated (MP) and conventionally propagated (CP) plants of 11 strawberry cultivars currently in commercial production in eastern Canada were compared on the basis of their runner plant and fruit production. MP plants of 10 cultivars produced more runners than CP plants by the fall of the planting year (1983). Increases in runner production varied from 6 to 61% among various cultivars. Marketable fruit yields in the year after planting were numerically higher in MP plants of 10 of the 11 cultivars and significantly higher in 6 of the 10. In most cultivars, berry size tended to be smaller in MP than in CP plants, but these differences were significant for only four cultivars. No off-types were seen among the MP plants.

CEREALS

Victoria field peas. The Swedish cultivar Victoria was licensed in April 1984. This was a result of the evaluation work coordinated from Nappan and carried out at three other locations in the region. It is a small to medium yellow round pea with acceptable cooking quality and moderately high in protein content. Four select plots were established in 1984. Quantitites of seed should be available in 1986.

Intensive management of barley. Intensive management (ICM) was used on one-half of the regional trial at Nappan in 1984, with only 8 of the 21 two-row barley entries and 3 of the 4 six-row entries showing a positive effect from the treatments. The treatments include the growth regulator Cerone, the fungicide Tilt, and extra N at 40 kg/ha.

Floret fertility in the winter wheat ear: An important determinant of yield response to ICM input. Floret fertility (measured as number of kernels per spikelet) in the winter wheat ear has been partitioned into two components to assist in assessing the effects of ICM. These components are floret fertility in the two spikelets at the midpoint of the rachis and average floret fertility distributed over all spikelets of the ear. Multiple fungicide applications effective in disease (mildew and *Septoria*) control achieved high rates of midpoint but low rates of whole-ear floret fertility, indicating a sharp distal fall in fertility in the ear. Single fungicides, applied either early to control mildew or late to control ear-borne *Septoria*, generated less midpoint fertility which, however, was preserved more uniformly throughout the ear thereby generating more kernels per ear than the pathogically effective split applications. Yields were closely associated with whole-ear floret fertility in such a way that disease-controlling methods generated yields in the order mildew control > *Septoria* control > mildew + *Septoria* control. It is concluded that split fungicide applications lose their effectiveness because in the Annapolis Valley environment, they impose stresses exhibited in the ear's inability to sustain adequate rates of floret fertility

as anthesis progresses towards the distal spikelets. A similar analysis applied to growth regulators indicates that effects on floret fertility are important here too. Furthermore, extension of this analysis to fungicide–growth regulator interactions explains why vegetative mildew control and Cycocel growth regulation appear to be minimally stressful while consistently generating the highest yields.

Effective growth regulation of winter wheat with early Cycocel application. The time for effective Cycocel growth regulation of winter wheat has been presumed to be short, with recommendation to apply shortly after tillering, when pseudostems have elongated to 5–10 cm. Evidence from 1983 experiments indicated that Cycocel had long-lasting growth regulatory effects capable of significantly shortening the peduncle. Applications of Cycocel extra (with active ingredient (a.i.) at 1.38 kg/ha) in 1984 on Ural, Monopol, and Borden at mid tillering effected shortening equivalent to application at early stem extension. Moreover, the relative pattern of internode and peduncle shortening was not obviously different between early and conventional applications. Growth regulation with Cycocel is therefore possible in principle, with application times 2–3 weeks earlier than current recommendations, offering the grower an opportunity of extending application time.

Overwintering nitrate assimilation potential. An in vivo assay indicated the presence of significant nitrate reductase activity in overwintering stands of Lennox, Vuka, Monopol, Absolvent, Ural, and Borden winter wheats in 1983–1984 and 1984–1985. Samples from stands approaching winter differentially lost nitrate-reducing activity in the absence of exogenous substrate, indicating a decline in metabolically available nitrate but a preservation of enzymatic potential for nitrate reduction. Application of N fertilizer in the spring of 1984 was quickly reflected in high induced levels of enzyme activity and in high levels of metabolically available nitrate associated with the onset of spring regrowth. Ammonium- or nitrate-based fertilizers were not differentiated, and therefore the effectiveness of ammonium in stimulating spring regrowth was related to its prior nitrification in the soil and its uptake and translocation as nitrate.

Apples

Of the nine cultivars grown commercially in Nova Scotia, Gravenstein, Wayne, and Northern Spy were the most sensitive to the low-temperature stresses of December 1980. King and Golden Delicious were less sensitive, and McIntosh, Red Delicious, Spartan, and Cortland averaged less than 8% lower trunk damage. No injury could be found in the rootstock at or just below the soil line. The minimum temperature for December 1980 was –23.0°C, on the 26th.

ORNAMENTALS

The influence of various levels and timing of supplemental irradiation on pot chrysanthemum production. Previous studies have suggested that maximum economic benefits associated with winter supplemental irradiation of pot chrysanthemums will occur when treatments are applied during rooting and long day (LD) production periods. Further studies with the cultivar Paragon have indicated that relative growth rate, final vegetative and flower dry weight, and number of breaks of flowering stems are significantly increased by supplemental irradiance of 77 μmol $s^{-1}m^{-2}$ (400–700 nm) during either rooting, LD, and 14 short days (SD). Increasing the level of supplemental irradiation to 148 or 231 μmol $s^{-1}m^{-2}$ generally had no further effect on harvest traits. Combined treatments of 77 μmol $s^{-1}m^{-2}$ applied during rooting and LD resulted in the most significant improvements in harvest traits over the controls. Extension of the treatment into SD, however, only resulted in further increases on stem length and vegetative dry weight.

Gypsophila paniculata production during fall and winter. Gypsophila paniculata production in northern greenhouses is generally limited to the spring, with maximum flower production in June. Since flowering is dependent upon both the duration and intensity of available photosynthetically active radiation (PAR), it has been difficult to schedule production for other times of the year. Vigorous vegetative growth necessitates wide spacing of plants in the greenhouse, which has precluded the straightforward use of high intensity discharge (HID) lamps to induce flowering. An alternative approach using HID supplemental radiation on containerized plants prior to transplanting to ground beds was investigated as a means of promoting flowering under unfavorable seasonal light conditions. Plants of the cultivar Bristol Fairy were subjected to 3, 6, or 9 wk of supplemental PAR (80 μmol $s^{-1}m^{-2}$) or to ambient irradiance (16-h photoperiod maintained with incandescent lamps) during October and November. Flowering did not occur in the ambient irradiance group and occurred in only 75% of plants in the 3-wk group. The most effective treatments were either 6 or 9 wk of supple-

mental PAR, both of which resulted in 100% plants flowering with acceptable yields. Such pretreatment of *Gypsophila* may be useful in extending the production season and scheduling flower data to match periods of highest demand.

Tissue nutrient content and growth of Andorra juniper influenced by controlled-release fertilizers. Andorra juniper grown in containers in a 2:1:1 bark–peat–sand medium produced most seasonal branch growth with Osmocote 18-6-12 or Osmocote 17-7-12 controlled release fertilizer (CRF). Both formulations were effective in maintaining tissue nitrogen concentrations at approximately 2.0% tissue dry weight throughout the season. Other fertilizers tested (Agriform 16-7-12; Sierrablen 18-7-10; IBDU 31-0-0; MagAmp 7-40-6; and SCU 36-0-0) were less effective in maintaining growth rates, and in many cases nutrient concentrations N, P, and K in the tissues decreased markedly towards the late season. The rate of application of CRF (N at 0.6, 0.9, or 1.2 g/L of medium) had relatively little effect on growth, although with Osmocote 18-6-12 or 17-7-12 growth rates were highest with N at either 0.9 or 1.2 g.

Irradiance and solution temperature effects on chrysanthemum production in nutrient film. Greenhouse chrysanthemums (cultivar Polaris) produced during the fall in flowing nutrient solution (NFT) produced greatest stem height and number of flowers when subjected to supplemental irradiation of 80 μmol $s^{-1}m^{-2}$ (400–700 nm) during rooting, 14 LD, and 9 SD. Warming the solution from 20° to 30°C decreased leaf area and the time to full flower development. Plants grown at 30°C also produced slightly more flowers per stem. Flower production is possible with this cultivar under ambient light conditions in autumn at 45°N latitude provided that root zone temperature is not permitted to drop below 20°C. Improved flower production and quality, however, will be achieved by short-term supplemental irradiation and a solution temperature of 30°C.

VEGETABLES

Cultivar evaluation. Trials included 642 cultivars of the following crops: asparagus, beans (snap), broccoli, Brussels sprouts, cabbage, carrots, cauliflower, corn, muskmelon, onions, parsnips, peas, tomatoes, and watermelon. Reports for each crop are available.

Multiple plants per transplant unit for broccoli production. With the cultivar Premium Crop, the use of two or three plants per treatment unit gave yields of terminal heads 38–60% higher than those of single plants at a plant × row spacing of 37.5 × 75 cm. At 45 × 90 cm, multiple plants yielded 50–78% higher than single plants. At both of these spacings, multiple plants gave yields that were at least as high as those of single plants spaced 30 × 60 cm. The savings in number of transplant units required at 37 × 75 cm and 45 × 90 cm compared with 30 × 60 are 47 and 67%, respectively. Results were similar for both Kord 809 cells, with a volume of 53 cm^3 per cell, and smaller Plastomer 200 cells with 29 cm^3 per cell.

Favorable results with the use of multiple plants were also obtained with the cultivars SG1, Kayak, Septal, Southern Comet, Laser, and Green Hornet. At a spacing of 45 × 90 cm, multiple plants of these cultivars yielded 11–68% higher than single plants.

Plastic row covers advance maturity of carrots. Plots with all types of covers gave higher yields of marketable carrots than unprotected plots on a 15 August harvest date with the cultivars Klondike Nantes and Scarlet Nantes Touchon. Covers included the commercial materials Xiro, ASB, Agplast, and Reemay as unsupported or "floating" covers; and ASB, Agplast, Reemay, a slitted material, and a solid plastic as covers for individual-row tunnels. Tunnels were ventilated when inside temperatures exceeded 35°C, but to minimize the number of times they were opened, tunnels were left open along one side much of the time. Tunnels showed no yield advantage over the unsupported covers and are more expensive to install and maintain. Plots with ASB, Agplast, and Reemay as unsupported covers tended to give the highest early yields, and their yields of 32–36 t/ha were 25–43% higher than the 25–26 t/ha for uncovered check plots.

Effects of various row covers in advancing maturity of rutabagas. Row covers included the commercial materials Xiro, ASB, Agplast, and Reemay as unsupported or "floating" covers; and Agplast, Reemay, and a solid plastic as covers for individual-row tunnels. Tunnels were ventilated when inside temperatures exceeded 35°C, but were left open along one side much of the time to minimize the frequency of opening and closing. With the cultivar York, only Reemay tunnel plots gave higher yields than uncovered plots on the 9 August harvest date. Their yield of 52 t/ha was 37% higher than the 38 t/ha obtained for check plots. With the cultivar Altasweet, Reemay, both unsupported and with row tunnels, gave yields of 39–40 t/ha, which were 28% higher than the 31 t/ha of check plots.

PROTECTION OF CROPS AGAINST PESTS

Plant pathology

Benomyl tolerance in apple scab. Tolerance of the apple scab fungus *Venturia inaequalis* (Cke.) Wint. to the fungicide benomyl is very persistent in an individual apple orchard. In 1982 when benomyl tolerance was first evident by lack of scab control, 100% of the scab isolates were tolerant. Benomyl was not used in 1983 and 1984 but 92 and 80%, respectively, of the isolates were still tolerant of benomyl.

Evaluation of fungicides on apples. Under extreme disease pressure, apple scab control with many of the experimental sterol inhibitor fungicides was unacceptable. The timing of the sprays in relation to apple scab infection periods necessitated more persistence than they provided under the conditions they were applied. The standard captan performed well in relation to most materials both alone and in combination with the sterol inhibitor, bitertanol and RO15-1297 (Maag).

Control of twig and blossom blight of lowbush blueberries. Two applications of Funginex 190 EC with a.i. in a series of decreasing rates from 0.32 to 0.09 kg/ha resulted in a curvilinear increase in the incidence of blighted leaf shoots and mummy berries and a linear increase in the incidence of blighted blossom clusters caused by *Monilinia vaccinii-corymbosi* (Reade) Honey. Quadratic equations describing the curvilinear disease response indicated a marked decrease in disease control at rates of a.i. below 0.27 kg/ha. Two additional applications of Ferbam 76 WP with a.i. at 2.25 kg/ha did not further reduce incidence of mummy berries. In a separate trial, Funginex was superior to Difolatan, Rovral, and Ronilan in controlling disease.

Mycocentrospora acerina associated with storage rot of carrot. Licorice rot (firm black lesions of the crown, side, and tip) incited by *M. acerina* was found on Newfoundland carrots after 5–8 mo of storage at 0–1°C; no symptoms had been observed at harvest. Although the disease has been reported previously in Canada, this report is the first from the Atlantic Provinces. The incidence was as high as one-third of the crop.

Efficacy of Rovral 50 WP (iprodione) for control of cabbage decay. The cabbage cultivar Houston Evergreen was left untreated or dipped in a solution with iprodione as a.i. at 500 mg/L and stored 10 mo at 2°C. The treatment, which reduces storage rot caused by *Botrytis* and *Alternaria* in shorter trials, was no longer effective after 10 mo.

Delaying fungicide application by 5 mo also was ineffective. All heads were badly decayed, and all treatments had decay in excess of 50%, indicating that a storage of 10 mo is longer than practical unless lower storage temperatures are used.

Septoria nodorum (glume blotch) of winter wheat treated with Cycocel Extra (chlormequat chloride). At the recommended rate of chlormequat chloride as a.i at 1380 g/ha applied at the second node growth stage reduced the height of the cultivar Absolvent at maturity by 7 cm but did not affect the percentage of glume blotch head infection, which was 5%. Four times the recommended ratio applied at first node to the cultivar Monopol reduced its height by 4 cm but did not affect the level of glume blotch, which was 10%.

Sugar analogue inhibition of vegetable decay organisms. 3-0-Methyl-D-glucose at 0.4% in agar gave 100% inhibition of mycelial growth of *Botrytis cinera* and 50% inhibition of *Alternaria alternata*. Dipping Brussels sprouts in 25% sugar analogue prevented decay incited by artificial inoculation of *B. cinera*.

Powdery mildew of winter wheat treated with Bayleton (triademefon) or Calixin (tridemorph). Triadimefon as a.i. at a rate of 125 g/ha reduced *Erysiphe graminis* f. sp. *tritici* (powdery mildew) to zero or trace levels on the flag leaves and whole plants of the cultivars Monopol and Absolvent. Tridemorph also gave adequate control, but levels were reduced only to 1–3% infection.

Evaluation of nuarimol winter wheat seed treatments. Five formulations were tested. All produced adequate autumn control but little or no spring control of powdery mildew on the cultivar Absolvent. There were significant differences in yield among formulations, with a 7.5% flowable preparation having the highest yield and a 10% drillbox dust having the lowest yield.

INSECT PESTS

Blueberry maggot control. One spray of dimethoate 480 EC, 500 mL/ha, applied 7–12 days after the first adult captures on Pherocon AM traps provided good to excellent control of the blueberry maggot in six fields in Nova Scotia and five in New Brunswick. The spray was applied with a tractor-mounted automatic mist blower equipped with a micronair head, which was calibrated to provide coverage for up to 30 m. The

sprayer is ideal for use in fields that can be sprayed from the perimeters and access roads, and in those that cannot be sprayed from the air.

Imported parasite release against apple leaf curling midge in New Brunswick. The parasites *Platygaster marchali* and *Inastemma contariniae* have been imported from Italy and released for 4 yr in New Brunswick orchards—two releases in the Keswick Ridge area and two in the Gagetown area—in an attempt to biologically control the apple leaf curling midge, *Dasineura mali*. Successful recoveries were made in 1983 from the 1981–1982 site indicating establishment. No recoveries were made in 1984 from either site mainly because of low host populations. In 1985 releases will be made in the Moncton area of New Brunswick.

Pest management in apple orchards. Counts of 13 species of insects and mites, quantities and types of pesticides used, and levels of injury to fruit and foliage were recorded from 175 orchard blocks in 1983. The apple maggot, sampled six times by yellow sticky boards, reached or exceeded its economic threshold in 11–17% of the orchard blocks (total 86% for all six samples). Other species frequently reaching the threshold were the winter moth (83% of the blocks), codling moth (70%), speckled green fruitworm (64%), and the European red mite (36%). On average, there were 2.74 insecticide applications and 0.34 miticide applications per block. Most insecticide applications were directed against the winter moth (33%), the apple maggot (22.7%), the codling moth (17.6%), fruit-stinging mirids (13.9%), and the rosy apple aphid (7.56%). Mean insecticide costs (materials only) were $51.39/ha, whereas miticide costs were $18.60/ha. Apple injury at harvest was assessed by examining, in each orchard block, 50 fruits from each of 20 trees. Insect injury was found on 2.00% of the fruit and 3.74% of the apples showed scab injury. Counts of first- and second-generation tentiform leafminer indicated a 4th continuous yr of decline. Miners exceeded the economic injury level (EIL) of 1 viable mine per leaf in only 2 of the 175 orchard blocks. Levels of bronzing by the European red mite reached injurious levels in 16 blocks, and rust mite bronzing was economic in only 3 blocks. Speckling by the white apple leafhopper was sharply down from levels in 1980–1982.

Pesticide evaluation background to the successful evolution of the integrated spray program for tree fruits. Continuous evaluation of new and old pesticides against pests, predators, and parasites has maintained the integrated pest management for pest control in Nova Scotia apple orchards, which has been in effect for years, even with the advent and use of broadly toxic new chemicals such as the pyrethroids, organophosphates, and carbamates. These chemicals have been successfully introduced into the control programs without disturbing the natural balance. This is enhanced by the continued progress in the development of optimum timing, minimum dosages, and the development and monitoring of economic thresholds. No new pest species have become numerous, and all pest species are at low levels requiring minimal controls. Phytophagous mite problems have increased slightly and may require an annual treatment in some blocks. The role and usefulness of the chitin-inhibiting growth regulators, e.g. Dimilin, have been determined and their use in the program depends on registration.

HERBICIDES

Movement and persistence of Dinoseb in a silt loam potato soil. Movement and persistence of the preemergence herbicide Sinox PE and the preharvest vine-killing Sinox Generol applied either separately or in sequence to a silt loam soil revealed the highest residues in the upper 0–2.5-cm profile at all intervals after applications.

A simple and rapid thin-layer chromatographic detection technique for phenolic compounds. Microcrystalline cellulose chromatograms containing the developed phenols were exposed to bromine vapor, and after evaporating the excess they were sprayed with Congo red, methyl yellow, or Rose Bengal reagents. Phenolic spots appear as blue, pink, or white against red, yellow, or rose backgrounds, respectively. Phenol, *p*-nitrophenol, eugenol, vanillin, orcinol, arbutin, caffeic acid, DOPA, quercetin, quercitrin, gallic acid, phloretin, and phloridzin were among the compounds detected at submicrogram quantities.

The fluorescence of some derivatives of picloram in concentrated sulfuric acid. The herbicide picloram (4-amino-3,5,6-trichloropicolinic acid) and its methyl, isoctyl, and 2-ethylhexyl esters fluoresce yellow green, whereas 4-amino-3,5-dichloro-6-hydroxypicolinic acid fluoresces white in 36 *N* sulfuric acid. The test is amenable to quantitative fluorometry and useful in confirmatory tests and metabolism studies, thus minimizing the need for expensive radioactive compounds.

Thin-layer chromatographic separation and identification of carbofuran and two carbamate metabolites and their dinitrophenyl ethers. Resi-

dues of carbofuran and its hydroxy and keto carbamate metabolites from soil and several plant extracts were identified using *p*-nitrobenzene diazonium fluoroborate or 2,6-dibromobenzoquinone-4-chloroimine reagents. Further identification was made by preparing the dinitrophenyl ethers of the three compounds and chromatography on thin layers.

Separation and detection of the herbicide hexazinone and five of its metabolites. Hexazinone and five metabolites were separated using chloroform-methanol, ethyl acetate-methanol, and ethyl acetate-dichloromethane-ethanol on thin-layer chromatograms. The residues were detected with silver nitrate and phosphomolybdic acid reagents.

Effect of perforated plastic row covers on residues of DCPA (Dacthal) in soil and broccoli. Covers used to promote early growth significantly increased persistence of DCPA in soils and its residues in broccoli, although levels were far below allowable tolerances. Since the herbicide was shown to be subject to volatilization, and perhaps photodecompositon, the covers affected residues by "trapping" herbicide vapors and possibly screening UV light.

Controlling fall-germinating Poa spp. in winter cereals. Chlorsulfuron at 12 and 24 g/ha applied in early fall was found to be the most effective and safest of many graminicidol herbicides tested, although linuron, Blagal, and metribuzin were also effective. Regardless of herbicide, either preemergence or early postemergence applications were the most effective. All spring treatments gave poor control of *Poa* spp.

Using hexazinone in cranberries. When hexazinone was applied during frost protection irrigation period, 1 and 2 kg/ha gave selective control of *Spirea latifolia* when it was applied adsorbed to sand or applied as a spray but immediately followed by irrigation. In greenhouse trials, tolerance of hexazinone was low, suggesting field tolerance was related to hexazinone dilution in soil caused by irrigation, thereby limiting such treatments to areas where serious weed problems justify risk of injury.

Selective control of alders in lowbush blueberries. In fruited fields scheduled for burning, selective control of alders was obtained with foliarly applied 2,4-D, dicamba, or 2,4-D + dicamba in mid October, when blueberries had defoliated but alders still retained their leaves. Earlier treatments caused crop damage, but later treatments were not consistently effective.

ANIMAL SCIENCE

One hundred kilograms the most profitable weight to ship hogs. Pigs were slaughtered at 70, 80, 90, and 100 kg liveweight. Pigs slaughtered at 100 kg consumed more feed at a poorer feed efficiency but gained equally well as compared with the other treatments. They also had the highest grade index and were the most profitable when cost of production and returns per pig were calculated.

Fish silage as a protein source for swine. Incorporation of fish silage up to 10% dry matter (DM) of the diet provides a good source of protein for growing pigs. Feeding 10% fish silage resulted in no palatability problems and good growth performance of the pigs as compared with 15%. Addition of liquid glucose to the fish silage diets had no effect on palatability or growth performance.

Pigs reared in an open-front barn. The growth performance of growing pigs housed in an open-front barn was evaluated for 3 years. It appears that in summer, growth performance is equal to that in conventional facilities. In winter, however, a significant setback in growth rate and feed consumption resulted in the open-front barn.

Level of nutrition may affect age at puberty of gilts. Gilts that were limit fed to 85% of appetite were slower growing and had poorer feed conversions. Limit feeding also resulted in a 26-day delay in attaining puberty as compared with gilts fed ad libitum.

Method of boar exposure may affect age at puberty of gilts. Moving the gilts to a boar for 30 min per day for 10 days or moving a boar in with a group of gilts for 24 h per day for 10 days resulted in a higher percentage of gilts in heat by 270 days of age as compared with moving the boar to the gilts for 30 min per day, exposing the gilts to a group of boars, or not exposing boars to gilts.

The effects of various sources of dietary fat on general performance and carcass fatty acid composition of broiler chickens. Two experiments were conducted to estimate the effects of adding poultry grease (PG), beef tallow (BT), and pork lard (PL) singly or in combination with rapeseed oil (RSO) to starter and finisher diets fed to 3000 broiler chickens. Neither male nor female mortality was affected by the various dietary fat sources. Diets supplemented with a combination of BT and PL resulted in reduced female body weights compared with diets supplemented with either BT or PL as a single fat source. These

differences in body weight were significant ($P < 0.05$) at 28 but not at 48 days of age. A comparison of animal fats revealed that a combination of PG–BT–PL resulted in the best feed conversion but was not significantly ($P < 0.05$) different except when compared with diets supplemented with BT. Combining Tower RSO with each of the animal fats resulted in increased final female body weights, improved feed conversion, and financial returns. Only small differences were observed in the fatty acid composition of the neutral lipids among dietary treatments (Experiment 2), and in each case the composition of the diet reflected the composition of the fat making up the diet. Total carcass lipids were not significantly affected by dietary treatment, indicating that an array of fat sources and combinations can be used in poultry feed formulations without significantly affecting total carcass fat or its composition. Lipid class analysis of diet and carcass lipids indicated primarily triglycerides, with small amounts of polar lipids and free fatty acids and only minor differences among dietary treatments. Carcass moisture content was found to have a high negative correlation ($r = -0.86$) with carcass lipids, suggesting that a simple and rapid estimate of carcass fat of broilers might be made simply by determining carcass moisture.

Effect of various levels of dietary sorbic acid on general performance and incidence of leg abnormalities of commercial broilers reared to roaster weight. Two thousand male, day-old Hubbard chicks were housed in 20 pens (13.5 m^2) to evaluate the effects on performance and leg abnormalities of feeding dietary sorbic acid at 0, 200, 400, and 600 g/t of feed during the starter, grower, and finisher periods. These levels of dietary sorbic acid had no significant effect on live body weight, feed conversion, mortality, or the incidence of leg abnormalities of these chicken broilers reared to roaster weight.

The effect of energy in starter–grower diets on the performance of turkey broilers. Two thousand four hundred poults (1200 of each sex) of the Diamond White strain were housed in 48 pens to evaluate the effect on performance and financial returns of six different levels of metabolizable energy (ME) in each of six starter (11.30–12.35 MJ/kg) and six grower (12.14–13.19 MJ/kg) diets. Starter and grower diets were isonitrogenous at 29 and 24% protein, respectively. The common finisher diet had 18% protein and ME of 13.60 MJ/kg ME. Feed conversion and financial returns increased ($P < 0.05$) with increased dietary energy. Optimum performance based on liveweight, feed conversion, and financial returns was achieved with a starter–grower–finisher regimen with ME at 12.35, 13.19, and 13.60 MJ/kg.

Some aspects of the composition of avian ascitic fluid. Ascitic fluid from male Single Comb White Leghorn chickens fed a diet containing 20% by weight of rapeseed oil rich (51.6 weight percentage) in erucic (22:1ω9) acid contained 2.84 ± 0.09 g/dL protein and 2.55 ± 0.22 µg/mL DNA. A characteristic feature of ascitic fluid as compared with liver and plasma was its high polyunsaturates, low saturates, and low saturate-to-unsaturate ratio. In general, the fatty acid profile of ascitic fluid is more comparable to the fatty acid profile of plasma lipids than to that of liver lipids. These data suggest that there is no direct absorption of fat and transfer to the ascitic fluid.

The effects of dietary micronutrient, fat, and protein components in pelleted feeds on the incidence of sudden death syndrome and other traits among male broiler chickens. Three experiments involving 11 600 male broiler chickens sought to determine if the pelleting process affects the dietary micronutrient, fat, and protein components so that the incidence of sudden death syndrome is increased. Processed dietary micronutrient and fat components were not significantly associated with an increase in sudden death syndrome among broiler chickens. In one of the experiments, the incidence of sudden death syndrome was reduced ($P < 0.01$) when the dietry protein supplements (soybean meal, canola meal, and fishmeal) bypassed the pelleting process.

Effects of photoperiod, light intensity, and feed restriction on the performance of dwarf and normal maternal poultry meat genotypes. Performance of female chickens from a dwarf maternal genotype was compared with that from a normal commercial maternal genotype in a factorial experiment designed to estimate the combined effects of increasing photoperiod at 112 and 140 days of age, increasing light intensity at 112, 126, and 140 days of age, and restricting adult nutrient intake at conventional and 95% of conventional levels. Dwarf layers matured 1 wk earlier and exhibited better feed conversion than the normal layers, but body weights were lighter at all ages. Eggs produced by dwarf layers were smaller but had stronger shells as measured by specific gravity. Genotype × feed restriction interactions revealed that productivity of the dwarf layer was adversely affected by the 95% feeding rate; at conventional feeding rates the two genotypes were similar in performance. Increasing light-intensity days had no significant effect on the

measured traits. Increasing the photoperiod (140 versus 112 days) resulted in fewer double-yolked eggs and delayed sexual maturity, particularly for the dwarf genotype.

Sheep

Monensin as an effective coccidiostat. An experiment was conducted to determine the effect of monensin on coccidiostat discharge on feeder lambs. Four treatments were established: control; monensin at 8 mg/kg of feed; monensin at 16 mg/kg of feed; and monensin at 24 mg/kg of feed. The level monensin at 24 mg/kg of feed was the most effective in controlling coccidia oocyst discharge. There was a slight improvement in feed efficiency as the levels of monensin fed increased. It is difficult to determine whether the increase in feed efficiency was due to an improvement in rumen fermentation or to monensin's effect on oocyst shedding.

Complete pelleted diet versus the traditional diet of mash and hay. It has been reported that a complete pelleted diet may increase the incidence of rumen parakeratosis and liver abscesses. To determine the effect of pelleted feeds, 30 Suffolk-cross lambs were put on a feeding trial. Ten lambs received one of the following: a complete pelleted feed for 60 days; a traditional mash and hay diet for 60 days; or a complete, pelleted diet for 50 days followed by the mash and hay diet for an additional 30 days. There were no pathological findings of rumen parakeratosis or liver abscesses in any of the lamb rumens on this trial. The number of lambs on the experiment was small and the conclusion of no effect should be accepted with caution.

Grazing comparison of lambs with kale, tyfon, and annual ryegrass in the fall. Lambs grazing kale, tyfon, and annual ryegrass averaged 0.15, 0.18, and 0.06 average daily gains, respectively, over the fall grazing period from 21 September to 15 November. The annual ryegrass received no extra N and was at a disadvantage for its fall growth.

STORAGE AND PROCESSING

Apples

Application of edible coatings for the modified atmosphere storage of apples. Several coatings (Nutri Save ®) have been tested to investigate the effects of various formulations and film viscosities on internal oxygen and carbon dioxide concentrations in McIntosh apples. Coating formulation was found to directly influence the reduction of internal oxygen levels, irrespective of the viscosity or the thickness of the applied solution. Increasing the concentration of a single formulation decreased the permeability of the coating to oxygen. In a test on Idared apples using a single formulation, fruit firmness and retention of titratable acids were significantly enhanced by the addition of a 0.1% nonionic surfactant as compared with results for the identical formulation without a surfactant. In either case, significantly greater quality retention was observed by increasing the concentration of the active material in the dipping solution. Both the firmness and retention of titratable acids observed in this study for the CMCH-S5 formulation with surfactant added are considered to be commercially worthwhile. Work is now under way to test several promising formulations in quantities that are almost at a commercial scale.

Specific inhibitors of β-galactosidase isolated from apples identified as quercetin glycosides and chlorogenic acid. Organic solvent extracts of Spartan apples, which inhibit β-galactosidase of apples and suppress apple softening in storage, have been fractionated by chromatography on silica gel and acrylic ester resin sheets and columns. The major constituents of the extracts, chlorogenic acid, catechins, and quercetin glycosides, individually inhibit polyphenoloxidase-free preparations of β-galactosidase and suppress softening of Golden Delicious apples held at 20°C.

Retention of apple quality in controlled atmosphere storage using sequential atmosphere regimens. Initial storage of McIntosh apples in 1.5% CO_2 plus O_2 (3°C) reduced the rate of loss of titratable acids and of apple softening in subsequent 5.0% CO_2 plus 3.0% O_2 storage. The initial low-oxygen storage effects on loss of titratable acids were observed in 2 of 3 yr studied, whereas the effects on loss of firmness were consistent over 3 crop years. An initial low-oxygen storage treatment of Golden Delicious and Spartan cultivars was not effective in suppressing subsequent softening in conventional controlled atmosphere storage. Storage of McIntosh apples initially in 1.0% O_2 for 2–5 mo, followed by conventional controlled atmosphere storage, reduced the risk of low-oxygen injury and retained up to 90% of the firmness retention imparted by continuous very low oxygen storage.

Blueberries

Design of flotation separation system for removing moss from lowbush blueberries. A second, higher efficiency flotation separation system for removal of moss from lowbush blueberries was developed based on a prototype built in the

previous year. The system was designed to allow for maximum operational flexibility to enable testing of process parameters and to determine optimum process conditions. A berry submersion belt incorporated at the start of the tank improved the separation of the moss from the blueberries by utilizing both the buoyant and sinking forces of the berries and moss. The earlier prototype was strictly dependent on the ability of the moss to sink. A unit processing 5500–7000 kg/hr constructed for a local food processor was operated in the 1984 season with very positive results.

Quality evaluation of lowbush blueberry postharvest handling and processing procedures. Development of the methodology to assess processed lowbush blueberry quality, as well as to determine the range of the chosen parameters, was carried out using various grades of berries from three local processors. Quality evaluation included chemical parameters (percentage of soluble solids, percentage of titratable acidity, and pH), physical parameters (texture by Kramer Shear cell, drained weight, percentage of fruit crushed, weight loss), color evaluation (on whole and crushed berries, and juice), and sensory evaluation. Various aspects of existing postharvest handling and processing technology were evaluated to determine their effect on blueberry quality: field cleaning, precooling, time delay before processing, and processing (including dumping, washing, separating, freezing, and destemming). Results will be used to modify postharvest handling and processing techniques in order to improve final berry quality and reduce losses due to damage and shrinkage.

Blueberry juice product development. Research on lowbush blueberry juice processing and preliminary product formulations was conducted in a project supported by the Wild Blueberry Association of North America. Based on earlier work done at the Kentville Station in 1963, a number of juice extraction processes were investigated to determine their effect on juice yield and quality, and to determine optimum conditions. The major parameters tested included process temperature, enzyme treatment, grinding routine, mash predilution, and initial berry quality. Preliminary product formulation tests were subsequently conducted to determine the effects of sugar concentration, acid concentration, type of acid, and juice concentration on the beverage quality. A shelf-life study is being completed to evaluate the product stability under varying process and storage regimes and initial product formulations. The results of this study have been used by a local food processor as a basis for the production of a blueberry beverage to be marketed in early 1985.

Cabbage

Storage of prepackaged cabbage. Feasibility studies indicate that the requirement for costly high humidity [95% relative humidity (RH)] in cabbage storage can be circumvented by trimming and wrapping the heads in plastic wrap before storage. After 8 wk at –0.25°C and ca. 82% RH, evaporative losses were 0.8 and 8.0%, and losses to wilt and mold combined ranged from 1.2 to 3.0% and 7.0 to 10% in wrapped and unwrapped heads respectively, for Ultra Green and April Green cultivars. Eighteen percent of all wrapped heads and 72% of unwrapped heads required retrimming. Better color in prepackaged produce, as assessed by Hunterlab colorimeter readings, was attributed to the appreciable amounts of CO_2 (0.6–1.5%) that accumulated under plastic wrap in storage.

Rutabaga

Preharvest defoliation. For economic reasons, there is a growing interest in preharvest defoliation. In a recent study of a suspected synergistic effect between ethephon (E) and ammonium peroxydisulfate (AP, ap) on the defoliation of Laurentian rutabaga, E at 1250, 2500, and 5000 ppm and "persulfate" at 1.0% were applied in all combinations. There were 3 plots per treatment, 11 roots per plot, and 134 leaves per plot with a standard deviation of ± 6.84. When leaf-drop comparisons were made at each observation date, synergisms of 60–134% were evident within 3 days of spray applications; thereafter, drop rates tended towards additive proportions, with net gains averaging 14–21% across the 6-point 13-day observation period. Because younger leaves are much more firmly attached in rutabaga, a better assessment of synergism is made by comparing the numbers of roots in each treatment that attain complete or near complete defoliation (i.e. range, 93–100%). The results were as follows: E 1250 + ap > E 5000 + AP, E 2500 + AP, E 5000, E 2500 > E 1250 + AP, E 1250; E 2500 + ap > E 1250 + ap and that E 5000 + ap was much more powerful than any other treatment or treatment pair.

Thus, inexpensive ammonium peroxydisulfate can be used to replace ethephon with equivalent and synergistic advantage. The fact that synergism develops quickly and greatly speeds initial leaf fall allows for early assessment of application suitability. Human toxicity problems are not anticipated. It is anticipated that consideration may now be given to other crops heretofore beyond the economic limits of ethephon.

Strawberries

Evaluation of a mechanical strawberry declusterer and decapper. A strawberry declusterer and decapper were evaluated during the 1984 strawberry season for seven varieties (including Kent, K76-3, and Midway) and several harvest dates. The declusterer evaluation involved hand picking of berries in clusters; samples thus included stalks, green and overripe fruit, and some single berries. In all, 22 samples were run over the machine and then evaluated by separating the output into various categories. Over all runs, the breakdown of the output was as follows: 28% total cluster (double, triple, and more than triple clusters), 21% single berries, 4% cut or damaged berries, and 47% debris (stalks, rotten berries).

For the decapper evaluation, berries were handpicked in clusters and then hand declustered into single berries with stems. These berries (including those that were green or overripe) were run over the machine and various categories were collected: rollovers, rollbacks, and sortouts (green or rotten off the belt).

Efficiency was evaluated as finished fruit (percentage by weight of decapped fruit, i.e., fruit on the belt before sorting). Over 64 runs, finished fruit was 47%.

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Research Station, Fredericton, New Brunswick

PROFESSIONAL STAFF

Y. Martel,[1] BA, BSc(Agr), PhD	Director
L.W. Garber, BA, MEd	Administrative Officer
D.B. Gammon,[2] MA	Library Area Coordinator
R.C. Hurtubise, BSc	Information Officer
N. Taniguchi,[2] BLS	Librarian
D.A. Young, BSc, MSc, PhD	Officer in Charge, Benton Ridge

Potato Breeding

D.A. Young, BSc, MSc, PhD	Section Head; Breeding and genetics
R.H. Coffin, BSc, MSc, PhD	Breeding and evaluation
H. De Jong, BA, MS, PhD	Diploid breeding and genetics
A.M. Murphy, BSc, MSc	Disease screening
J.E.A. Seabrook, BSc, MSc, PhD	Propagation methods
G.C.C. Tai, BSc, MSc, PhD	Quantitative genetics
T.R. Tarn, BSc, PhD	Cytogenetics

Potato Pest Management

R.P. Singh, BSc(Agr), MSc(Agr), PhD	Section Head; Virus diseases, viroids
R.H. Bagnall, BSc, MSc, PhD	Virus epidemiology and resistance
G.Boiteau, BSc, MSc, PhD	Insect ecology
M.C. Clark, BSc, PhD	Biochemistry of disease resistance
W.K. Coleman, BSc, PhD	Physiology
R.R. King, BSc, MSc, PhD	Residue chemistry
A.R. McKenzie, BSc, MSc, PhD	Tuber-borne pathogens
Y. Pelletier, BSc, MSc	Insect–plant relationships

Livestock and Crops

J.W.G. Nicholson, BSc, MSc, PhD	Section Head; Meat animal nutrition
G. Bélanger,[3] BSc, MSc	Forage crops
P.L. Burgess, BSc, MSc, PhD	Dairy cattle nutrition
R.S. Bush,[4] BSA, MSc, PhD	Calf nutrition
R.E. McQueen, BSc, MSc, PhD	Rumen microbiology

Engineering, Horticulture, Soils

G.C. Misener, BSc, MSc, PhD	Section Head; Harvesting and storage engineering
T.L. Chow, BSc, PhD	Soil hydrology
E.N. Estabrooks, BSc, MSc	Tree fruits and berry crops

C.D. McLeod, BASc, MASc	Agricultural mechanization engineering
P.H. Milburn,[5] BSc, MSc	Soils engineering
J.E. Richards,[6] BSc, MSc	Soil fertility
G.R. Saini, BSc, MSc, PhD	Soil physics
G.W. Wood, BSc, MA, PhD	Blueberry pests
L. Woodrow,[7] BSc, MSc	Fruit crop winter hardiness

Senator Hervé J. Michaud Experimental Farm, Buctouche, N.B.

R. Rioux,[8] BA, BSc(Agr), MSc	Acting Superintendent; Forage and cereal crops
P.V. LeBlanc,[9] BSc, BSA	Vegetables
M. Luffman, BSc(Agr)	Fruits

Departures

C.S. Bernard, BSA, MSc, PhD Transferred to Regional Development Branch, Ottawa, Ont. February 1984	Director
G.R. Saini, BSc, MSc, PhD Retired July 1984	Soil physics
N. Taniguchi, BLS Resigned September 1984	Librarian
G.W. Wood, BSc, MA, PhD Retired January 1984	Blueberry pests

VISITING SCIENTISTS

National Research Council visiting fellow

J.D. Holley, BSc, MSc, PhD	Fungal epidemiology

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[1]Appointed June 1984.
[2]Seconded from Libraries Division, Finance and Administration Branch.
[3]Appointed July 1984.
[4]Returned from secondment to Management Accountability Directorate and Program Coordination April 1984.
[5]Appointed March 1984.
[6]Appointed September 1983, scientist in training.
[7]Appointed May 1983, scientist in training.
[8]Seconded from La Pocatière Experimental Farm.
[9]On education leave.

INTRODUCTION

The Fredericton Research Station conducts a comprehensive research program on potatoes, focusing a multidisciplinary effort on cultivar development and evaluation, tuber processing quality, disease control, pest management, rapid multiplication techniques, dormancy manipulation, harvesting and storage procedures, and soil utilization. Recently, emphasis has been placed on the seed potato sector of the industry, through the testing of Canadian genetic stocks in countries with import potential and related research in phytosanitary quality.

The livestock and livestock feeds program has, as its main goal, the efficient utilization of locally produced feeds, particularly forages, by ruminant animals. Aspects of herd management are also investigated. This research is pursued in close collaboration with the Nappan Experimental Farm, in Nova Scotia.

The horticultural program consists of research on blueberry crop management and pest control, and contributes to the program at the Kentville Research Station on apple orchard management and strawberry cultivar evaluation. To the horticultural program is added the research conducted at the Senator Hervé J. Michaud Experimental Farm in Buctouche, N.B., which is pertinent to requirements in that geographical area. The Michaud Farm's research summary appears in this report.

Soil scientists at Fredericton contribute to the maintenance and improvement of the agricultural land base in New Brunswick, and the work of analytical chemists includes the monitoring of degradation and residue products of chemicals and pesticides used either on the soil or on crops.

The results herein reported provide an overview of continuing research programs. More complete information can be obtained from the Research Station, Agriculture Canada, P.O. Box 20280, Fredericton, N.B. E3B 4Z7.

Y. Martel
Director

POTATO BREEDING

Diploid potato breeding. One of the major advantages of a breeding project on the diploid level is the genetic access to a large part of the vast pool of diploid germ plasm as it exists in Central and South America. A return to the tetraploid level (which is the ploidy level of North American and European cultivars) is possible through the so-called tetraploid-diploid hybridization ($4\times$-$2\times$) method, among others. Although this method has proved to be an effective means of conferring heterozygosity and hybrid vigor from the diploid parent to the (tetraploid) progeny of $4\times$-$2\times$ hybridizations, its wider implementation has thus far been limited by the lack of a large number of well-adapted diploid clones that produce a high proportion of $2n$ gametes. During 1984, 40 new diploid hybrids were identified that produce $>$ 15% large ($2n$) pollen. From among these, 11 clones have been selected and used very successfully in $4\times$-$2\times$ test crosses.

Potato species germ plasm collections. About 32 species of potato (tuber-bearing *Solanum*) are currently recognized in Mexico. Some of these, including *Solanum demissum*, *S. stoloniferum*, *S. verrucosum*, and *S. bulbocastanum* have been used in Canadian research on breeding for resistance to *Phytophthora infestans* and several viruses, and some already occur in the pedigrees of Canadian cultivars. Many of these species were inadequately represented in world germ plasm collections, and living material of some of the species was unknown. Accordingly, a series of germ plasm collecting expeditions was undertaken in 1982, 1983, and 1984 including the interregional potato introduction project of the U.S. Department of Agriculture, the potato program of Mexico's National Agricultural Research Institute (INIA), the Copenhagen University Botanical Garden, and Agriculture Canada's potato breeding program. A total of 304 collections were made from a wide variety of habitats, including xerophytic shrub vegetation, oak woods, and pine–fir forests, at elevations from 1500 m to over 3000 m in 20 states. In many places, including remote areas, changing land use was threatening habitats of potato species. Two species were collected as living material for the first time, and new collections of 24 species improved species representation and in some cases extended known distributions. Of the six species not collected, one was from an area not visited, two were rare hybrids, and intensive searches for the remaining three produced no results. Studies of the new collections indicate at least two new species. Living material is deposited with the Mexican and U.S. potato collections.

Development of performance models for potato genotypes tested in international trials. A series of international trials were conducted over the past 2 yr. The purpose of the experiments was twofold: to develop a method for obtaining environmental indices that measure productivity of diverse potato-growing areas; and to construct performance models for individual genotypes based on the environmental indices. Yield data of 29 genotypes obtained from a series of 12 experiments conducted in 8 countries in 1983 and 1984 were used in the study. The response pattern of the genotypes was studied by a multivariate analysis. Five genotypes were chosen as representatives for various response patterns to the environments, and their data were used for obtaining a series of independent indices for each of the experimental sites based on principal component analysis. Performance models for each of the genotypes were constructed by stepwise regression analysis of yields of a genotype on the environmental indices based on 1983 data. Yield data of 1984 experiments were used to verify the models. Satisfactory correspondence between observed and predicted yields was obtained for most of the genotypes.

A computer software system for registration of pedigrees of potato cultivars and parental lines. A software system has been developed for recording pedigrees of potato cultivars and parental lines. A data base was developed to store names of cultivars and parental lines and their two immediate parents. Synonyms of all names are carefully checked and included in the data base. Information regarding breeding lines and cultivars of uncertain parentage was also stored in the data base. A FORTRAN computer program is used to construct pedigree charts for specified cultivars or parental lines based on information in the data base. The system is valuable for conducting in-depth searches of parentage of specific breeding lines and for revealing the role of species and old parents in the pedigrees of current cultivars. It is also possible to calculate an index of inbreeding in a cultivar or parental line or the kinship between any two of them. This information assists the breeder to avoid crossing close relatives when planning the hybridization programs. The data base is also useful for studying the past utilization of wild potato species and primitive cultivars in breeding.

Survival of potato tuberlets of various sizes. The influence of tuber size on survival and subsequent shoot height of the cultivars Caribe, Jemseg, Katahdin, Kennebec, Sebago, Shepody, Red Pontiac, and Russet Burbank was examined.

Tuberlets 3.5–0.2 g in weight were produced by leaf-bud cuttings exposed to both long (16 h) and short (8 h) days. After refrigeration for 3 mo in plastic bags to break dormancy, the tuberlets were planted in the greenhouse in a loam–sand–peat–perlite mixture (6:1:1:4). The height and survival of the shoots arising from the tuberlets were assessed. The percentage of tuberlets surviving was considerably (50%) reduced in tuberlets of less than 0.5 g. There was a general reduction in live tuberlets that sprouted as they became smaller. The height of shoots from tuberlets at 4 wk after planting was directly proportional to the tuberlet size. Thus, survival and vigor are related to the size of greenhouse-grown leaf-bud tubers.

Influence of leaf shape of cuttings on leaf-bud tubers. Potato plants produce simple leaves with few leaflets when they first emerge. Later, more complex, compound leaves are formed that are usually larger than simple leaves. Leaf-bud cuttings prepared from simple and compound leaves were subjected to suitable day lengths to promote tuberization. Cuttings of the cultivars Caribe, Jemseg, Katahdin, Sable, Shepody, and Russet Burbank, prepared from both simple and compound leaves, produced tubers. However, cuttings of compound leaves formed considerably larger tubers than those composed of simple leaves. Thus, leaf shape cannot be used as an indication of a leaf-bud cutting's ability to tuberize, but can be used to provide tubers of optimum size.

High-performance liquid chromatography determination of ascorbic acid in potato tubers. Classically, a visual titration with 2,6-dichlorophenol has been the method of choice for the determination of ascorbic acid in potato tubers. However, this method is often complicated by the existence of interfering coextractives; it is nonspecific for ascorbic acid, and end points are ill-defined because problems with color development and fading are common. To alleviate these difficulties a high performance liquid chromatography (HPLC) procedure for the analysis was developed. The procedure involves isocratic separation of ascorbic acid from coextractives on a 10 μm Si-60 column using a 50:50 (vol/vol) methanol–trichloro-1,1,2-trifluoroethane solvent. The separation was accomplished in 5 min at a flow rate of 1 mL/min. Detection is based on the distinctive absorbance properties of ascorbic acid at λ_{max} 245 nm.

POTATO PEST MANAGEMENT

Solanum berthaultii: A necrotic host for viroids from citrus, chrysanthemum, potato, and tomato. A clone of *Solanum berthaultii* (USDA P.I. 265857) developed necrotic symptoms when infected with either mild or severe strains of potato spindle tuber viroid. It was sensitive enough to allow for the direct indexing of individual tubers using cut pieces or using nucleic acid extract for composite samples. *S. berthaultii* also developed necrotic symptoms when inoculated with citrus exocortis, chrysanthemum stunt, and tomato apical stunt viroids. However, *S. berthaultii* did not become infected and consequently it did not develop any symptoms when inoculated with chrysanthemum chlorotic mottle viroid either mechanically or by grafting. The symptoms in this clone for all viroids consisted of necrotic spotting of petioles and stems, along with leaf collapse. The necrotic, rolled leaves eventually dry out but they remain attached to the stem. Any new leaves were reduced in size and the entire plant was severely stunted.

Unsuitability of glycerol for the preservation of potato virus Y (PVY) and virus A (PVA). Glycerol has been used for the long-term preservation of purified stable plant viruses, but no information was available on its effect on labile viruses such as PVA and PVY. PVY was purified by two cycles of differential centrifugation in CsCl. The purified virus (2 mg/mL) was mixed with equal volumes of either glycerol or buffer and stored at 25, 4, –20, and –70°C. Samples were removed periodically from each temperature-storage regime and tested for infectivity based on local lesion and for serological reactions with the ELISA test. Both infectivity and ELISA readings were reduced in virus samples containing glycerol compared with buffer only samples. The diminished infectivity and ELISA readings occurred more readily at high temperature than at low. Similar results were obtained with purified PVA.

Factors affecting tuber-indexing of PVY by ELISA. Antiserum against PVY was shown to be specific for indexing infected tubers in the ELISA. Assays with antiserum did not result in measurable reaction when tested against uninfected tubers of 30 potato cultivars. Virus concentration did vary among the potato cultivars, depending upon whether the tuber samples included or excluded eye tissue. Incubation of tuber samples in microtiter plates at 37°C was preferable to incubation at 4°C. Tuber storage temperature, status of tuber surface, and presence or absence of sprouts were other important variables that affected the outcome of ELISA tests. Treatment of freshly harvested tubers with "rindite" did not improve the reliability of PVY tuber test either.

Successful management of the potato spindle tuber viroid (PSTV). An analysis of field inspection data over a period of 15 yr (1969–1983) of the New Brunswick seed potato crop showed that the incidence of PSTV had decreased to the point where it could not be detected by visual observation. This eradication of viroid in the seed potato crop could be attributed to higher standards or stricter regulations in seed certification programs, use of virus-free seed multiplied at Elite seed farms, enactment of provincial disease eradication acts, and strict plant requirements of processing companies in the region.

A survey of 100 fields of potatoes planted for processing purposes was made for the viroid in 1984. From each field, 500 leaflets were collected, and the nucleic acid was extracted from batches of 50 samples and tested for the presence or absence of viroid by indicator plants or by dot-blot test. No viroid was found in any samples. This further indicates that PSTV has been successfully controlled in potato seed production.

Progress in late blight research. Potato late blight research conducted for the past 10 yr at Fredericton was evaluated in relation to current literature. A research publication was prepared describing the late blight forecasting program developed here.

A modern weather data collecting device, the CR21 micrologger, was programmed and placed in the field for the first time in the summer of 1984. Relative humidity, leaf wetness, and temperature were measured and recorded every 15 min from 28 June to 7 September. Observations were stored on cassette tapes and entered into the Agrinet system, without manual transcription, using a translating device. The CR21 micrologger proved accurate and reliable and was maintained with ease in the field. Data from the CR21 and newer X21 can be transmitted continuously from remote locations via telephone line to an IBM PC or other similar desk-top computer. Current technology makes the collection of real-time data from many locations a reality. Availability of up-to-date data will be critical in improving the design and accuracy of the late blight forecasting program.

A computer program prepared for calculating daily late blight forecasts with an IBM PC was tested for accuracy and ease of use. The program that was prepared for use in Prince Edward Island is expected to improve the forecast service offered in that province. This program will be used in

future research at Fredericton and may eventually be used with data transmitted by telephone from remote microloggers to calculate daily forecasts.

Colorado potato beetle. A black-body mutant of the Colorado potato beetle has been isolated for the first time in North America. The recessive nature of the character and the lower viability of the eggs have been confirmed. Reciprocal crosses between the black, the wild, and a previously described white morph have been used to study the inheritance of color for the adult, its hemolymph, and the larvae and eggs. The presence of white beetles in the progeny of white females and black males is particularly interesting. The data support the hypothesis of a transient maternal influence in the first generation in this case.

Cultural practices and potato arthropods. Tests were conducted in 1981 and 1982 to determine the effect of cultural practices such as planting date, plant spacing, and weed control on beneficial and destructive insects of the potato crop. Results showed that within the present range of agronomic practices, the manipulation of seed spacing or changes in the acceptable degree of weed control will have little or no effect on potato arthropods. There is a tendency for increased populations of carabids in early planted potatoes, but their potential as biological control agents is limited by their susceptibility to herbicides. Based on our data, the suggestion that the advantages of controlling weeds with herbicides can be offset by the increased vulnerability of weed-free crops to aphid vectors does not apply to the potato crop in such regions as New Brunswick, where the primary aphid flights occur early (before any significant weed cover can be established) and where, because of the short season, the canopy closes relatively quickly. It may be possible to delay planting to control the negative effect of aphid populations when producing small, whole seeds because they require a shorter growing season than cut seeds. This production is limited now but could become important.

Behavioral effects of Aldicarb on two potato aphids. Previous statements regarding the lack of immediate effect of systemic insecticides have been substantiated under field conditions. Under New Brunswick conditions it takes a minimum of 30 h to reach 50% mortality of winged green peach aphids. Further, laboratory tests showed that only 45% of the green peach aphids and 40% of the common potato aphids were able to fly following a sublethal exposure to aldicarb. Aphids unable to fly became hyperactive but did not probe. According to our data the effective control of leafroll spread within fields by aldicarb results not only from a reduction in number of aphids but also from a reduced ability to probe and fly from plant to plant.

LIVESTOCK AND CROPS

Barley and wheat head chop silages. Crops of barley and wheat were chopped with a modified forage harvester equipped with a direct-cut head attachment and ensiled in upright concrete silos at 42% dry matter. The cutting knife of the harvester was raised so that only the grain heads plus approximately 15–20 cm of straw were removed. Twenty-four cows were randomly divided into three groups and fed one of the following: grass silage ad libitum (control), barley, or wheat head chop silage (22 kg per cow per day) plus ad libitum grass silage for a 12-wk period. Concentrate was fed to each group according to milk production and to balance energy and protein intake.

Total dry-matter intake was similar for grass and barley silages but lower ($P < 0.01$) for wheat head chop silage. Forage dry-matter intake (head chop silage plus grass silage) was highest for barley, intermediate for wheat, and lowest for the grass silage control group. Intake of both barley and wheat head chop silages sharply reduced grass silage intake. Daily milk yields (4% fat corrected) were not different for the three treatments (25.0 kg per day). Cows consuming the wheat silage had higher ($P < 0.01$) milk fat, rumen ammonia, and butyrate levels, whereas ratios of rumen acetate-to-propionate were lower ($P < 0.01$) for barley silage. Barley head chop silage was rated superior to wheat in terms of performance for lactating dairy cows.

Nitrates in annual ryegrass. Annual ryegrass has received a lot of interest recently as a supplementary forage crop in the Atlantic Provinces. It responds well to nitrogen fertilization in terms of yield and crude protein content when growing conditions are optimal. However, when conditions are unfavorable, heavy nitrogen fertilization may lead to a high level of nitrate nitrogen in the forage.

Aubade ryegrass was grown with three levels of nitrogen fertilization (168, 336, and 504 kg/ha) each applied at three periods of time; mid June, after first cut, and after second cut. The yields of dry matter did not respond to the high nitrogen fertilization except for cut 1. There was a gradual increase in total nitrogen, nonprotein nitrogen, true protein, and nitrate nitrogen from cut 1 to cut 3 and from the control level to the high level of nitrogen fertilization. The level of nitrate-nitrogen was potentially toxic for the later cuts of

forage grown with the higher levels of nitrogen fertilization. Values of nitrate nitrogen as high as 0.4% of dry matter were recorded. Forages that contain more than 0.15% nitrate nitrogen should not be fed to pregnant animals, and levels over 0.4% are potentially toxic to all animals.

Effect of ground annual ryegrass in calf rations. A calf starter ration was formulated containing 15% soybean meal (SBM) and 15% ground timothy. This was compared to a ration with 33% SBM and the timothy replaced by ground annual ryegrass (RG). Both rations were fed in mash and pelleted forms to calves from birth to 84 days of age.

Calves fed the RG ration grew as fast after weaning (28 days of age) as those fed the SBM ration. Before weaning the RG groups grew faster, but this cannot be attributed to the diet. Calves fed the pelleted diets had lower rumen pH than those fed the mash diets. This decreased pH also resulted in lower ratios of acetate to propionate in the rumen fluid due to increased propionate concentration. There was also a trend toward lower total volatile fatty acids (VFAs) in the rumen of the RG calves. These results suggest that the RG protein was sufficiently digestible so that annual ryegrass could replace at least one-third of the soybean meal in calf starter rations without hampering performance.

Fish-meal gruel for calves. When calves drink milk, the esophageal groove reflex ensures that the milk passes directly into the true stomach and the milk proteins are not subjected to deamination in the rumen. On the other hand, when calves eat dry feed it goes directly to the rumen, and some of the valuable protein is destroyed by the rumen bacteria.

As part of a larger study on use of over-quota milk, we fed some calves a high-quality fish meal mixed with water to form a gruel. Starting at 28 days of age, the milk allowance was gradually reduced and replaced with the fish-meal gruel. It was hoped that the esophageal groove reflex would continue to function and the fish meal would bypass the rumen. Considerable difficulty was encountered in getting the calves to consume the fish-meal gruel when it replaced all the milk.

Calves fed whole milk to supply the same amount of protein as fed in the fish meal grew significantly ($P < 0.01$) faster (148 versus 120 kg) from 28 days to 6 mo of age. In fact, calves fed dry fish-meal as well as their starter also grew faster ($P < 0.05$, 128 kg), but the control calves fed a 15% crude protein starter grew more slowly ($P < 0.01$, 97 kg) than all other groups.

There was no advantage to feeding the fish meal as a gruel rather than the dry meal.

Digestibility by pigs of potato steam peel. Potato steam peel is a by-product of processing potatoes for the production of frozen french fries. It is partly cooked and should be a useful feed for pigs. If it can be used successfully, enough steam peel is produced in New Brunswick to replace about 10% of all the grain fed to pigs in the province.

A digestibility trial carried out at this station showed that the dry matter was digested to the extent of 81% but that the digestibility of the protein was only 61% by pigs. However, the peel dry matter contains about 15% crude protein, and so it is still a good source of digestible crude protein. Feeding trials carried out on a cooperative farm showed pigs will readily consume liquid diets containing up to 20% of the dry matter from potato steam peel.

Carbohydrate content and buffering capacity of silage crops. The water soluble carbohydrate and starch (WSS) content of four forages was determined at various times during the day and in sunny and cloudy weather. The forages were frozen with liquid nitrogen immediately after cutting, then freeze-dried. The WSS content was measured as glucose in the aqueous extract following 6 h reflux with water and 24 h digestion with amyloglucosidase. The forages were cut at 8:00 a.m., 11:00 a.m., 1:00 p.m., and 4:00 p.m. on 5 July, which had 12.4 h of sunshine and on 7 July, which had only 2.6 h sunshine. The two red clover cultivars (Hungarpoli and Ottawa) were past full bloom, with over half the blossoms turning brown. Annual ryegrass was at the joint stage and Climax timothy was in full head but not in bloom. Both red clover cultivars had a higher WSS content than did the grasses. The hours of sunlight had no effect on WSS, but on both sampling days WSS content at 11:00 a.m., 1:00 p.m. and 4:00 p.m. was greater than at 8:00 a.m. in all forages. The WSS contents of leaves and stems of the grasses were not different, but the stems of the red clovers contained about twice the WSS content as did their leaves. Thus in preparing red clover ensilage, the stems should be chopped and crushed to ensure the availability of WSS for fermentation. The levan content of forages was not determined. The buffering capacity of the forages was determined as the milliequivalent of H^2SO^4 required to obtain a pH of 4.0 in an aqueous mixture of 100 g forage. Buffering capacity was not affected by the duration of sunshine or by cutting time during the day. Climax timothy had a lower buffering capacity (183.5 meq/100 g) than annual ryegrass (463.4 meq/100 g) or than either red clover cultivar (average 398.6 meq/100 g). The high buffering capacity of

the red clovers, even at advanced maturity, and of the immature annual ryegrass would tend to make these crops more difficult to ensile.

Changes in rumen epithelial enzyme profiles with development. The specific activity (units of activity per milligram of protein) was measured for 11 enzymes in crude extracts of the rumen epithelium from mature and newborn cows. The activities from three different extracts were found to be quite similar. When the average values for the mature cow and the newborn preruminant were expressed as a ratio, there were three distinct groups (0.2–0.8; 1.0–2.2; and 8–10). The low ratio group included the enzymes glucose-6-phosphate dehydrogenase (0.2), pyruvate kinase (0.3), and glyceraldehyde-3-phosphate dehydrogenase (0.8). The high ratio group included the enzymes glutamate-pyruvate transaminase (8.1) and alkaline phosphatase (9.3). These results suggest that the enzymes of the low ratio group, which are involved in carbohydrate metabolism, are more important to the young calf. The enzymes of the high ratio group are more important to the mature cow. The other enzymes examined are probably required for metabolism at all stages of epithelial development, and therefore activity does not change appreciably.

Chemical deoxygenation of the epoxide moiety in deoxynivalenol (vomitoxin). Investigations involving incubation of deoxynivalenol in vitro with rumen microorganisms demonstrated that the predominant biotransformation consisted of deoxygenation of the 12,13-epoxide moiety to a 12,13-double bond. Since there is strong evidence to suggest that the toxicity of trichothecenes is conferred by the 12,13-epoxide group and that elimination of it substantially detoxifies the substance, we undertook preparation of a sufficient quantity of the deoxygenated derivative in order to determine its relative toxicity. The preparation involved initial reaction of triacetoxydeoxynivalenol with hydrobromic acid-acetic acid at reflux temperatures. This treatment yielded a 2-bromoapothrichothecene and a 13,12-bromohydrinthrichothecene as the major products. Dehalohydrination of the 13,12-bromohydrin derivative with zinc-acetic acid, then deacetylation with sodium ethoxide gave the required compound in quantities sufficient for toxicological testing.

ENGINEERING, HORTICULTURE, AND SOILS

Potato harvester shares. During the development of prototype potato harvesting equipment, the first component studied in detail was the potato digging share. Five vibrating sieving shares for lifting potatoes were designed, constructed, and tested on a potato harvester. The most successful model for smooth material flow into the harvester caused unacceptable skinning injury, whereas the model with the least injury had unacceptable flow characteristics. All models were vibrated in the horizontal plane to avoid possible damage from motion in the gravitational direction. The objective of increasing soil sieving rates on the harvester was achieved. However, problems with material flow at the harvester inlet limits the application.

Lowbush blueberry stripper. In the search for alternative harvesting techniques, with particular emphasis on the fresh fruit lowbush blueberry, there was a need to evaluate the possibility of harvesting the entire plant and separating the plant and blueberry under less demanding circumstances. A stripper for lowbush blueberry removal was designed, constructed, and tested. It demonstrated the technical feasibility of removing the berries from the plant after it was cut. During a series of tests, up to 92% of the marketable berries were removed after nine sets of stripping fingers passed through the plants. The harvested berry quality was comparable to the hand-raked product. To improve product quality, softer materials for the stripping fingers will be investigated.

Effect of soil mixed with bulk potatoes on air flow resistance. Equations were developed for predicting the pressure drop of air flowing through bulk potatoes. The pressure drop was a function of air flow rates and of various levels of soil–potato mixtures. Adding a small amount of loose dirt to the clean potatoes significantly increased the air flow resistance in the potato pile.

The study indicated that a soil-to-potato ratio change from 0 to 2% doubled the air pressure drop. The results suggest that fan capacity may have to increase to ensure adequate air flow when soil adheres to the tubers during harvest.

Cold resistance among apple cultivars during deacclimation. One-year-old samples of vegetative twigs from mature, bearing trees of nine apple cultivars were monitored over 2 yr for their dormancy intensity and relative coldhardiness levels during the winter–spring deacclimination period. The apple cultivars exhibited a consistent response during the dehardening process, which included increased percentage of moisture content, a higher initiation temperature for the low temperature exotherm (LT_2), and the development of an intermediate freezing exotherm (LT_1). Imperial Red Mac–Antonovka was the hardiest

cultivar during the 2-yr period, and Imperial Red Mac–M.111 was the most tender.

Cortland–Beautiful Aracade and Rogers Red Mac–M.111 varied considerably in their relative hardiness responses from year to year. Midwinter hardiness levels were significantly and positively correlated with dormancy intensity in the nine cultivars. However, this relationship did not exist when the hardiness indices for late winter or early spring were compared with dormancy intensity.

Chemical modification of coldhardiness in apple trees in eastern Canada. An examination of historical winter injury patterns in New Brunswick revealed that there was, on average, a severe occurrence once every 6 yr. These events appeared to be primarily associated with late winter–early spring shoot damage when the shoots are nondormant and deacclimating.

Alar-85® and surfactant WK® accelerated the onset of cold hardening within 2 wk of chemical application during the fall period. However, neither chemical treatment was able to modify subsequent spring bud break or to increase the coldhardiness level relative to the untreated trees during the late winter and early spring. Since the beneficial effects of these chemicals when used alone appear to be restricted to the late fall early–winter period, they should be useful in such areas as Nova Scotia, where most freezing may occur in the fall.

Soil resources of Agriculture Canada research establishments in Buctouche and Fredericton.[1] The soils of the Senator Hervé J. Michaud Experimental Farm were found to be typical of those in the surrounding regions of the eastern coastal plain of New Brunswick. Inherent soil factors significantly limit the potential for agricultural productivity. Dense, compact (bulk density 1.8–2.0 g/cm^3), relatively impermeable (saturated hydraulic conductivity of less than 0.1 cm/h) lodgment till subsoil is probably the most detrimental factor limiting soil agricultural capability. Excess soil moisture is directly related to this. Low natural fertility due to a lack of available nutrients, high acidity, and low exchange capacity are also problems. For more information the reader is referred to *Soils of Senator Hervé J. Michaud Experimental Farm, Agriculture Canada, Buctouche, N.B.*

Soil types found on the Fredericton Research Station are representative of most of the major agricultural soils found in New Brunswick. This variety of soil materials allows for experimentation and field trials under a number of different soil conditions. However, with such diversity of soil materials, it becomes all the more important to ensure that comparison trials are conducted on the same type of soil. Soils information will play an important role in the planning of future research, especially in the selection and location of experimental fields and plots.

The detailed soil resource inventories now available for these two research centers will allow for the extrapolation and transfer of research findings to areas of similar soil types within the region and will provide a basis for sound, rational farm management.

Agricultural land base of New Brunswick. Based on the concept of the agriculturally blocked land, which is a grouping of lands according to their capability and socioeconomic characteristics, the existing and potential farm lands consist of a total of approximately 1.7 million ha. On this land, more than 88% of the soil materials are developed from glacial tills, over 52% of which are derived from compact basal till. With the exception of coarse fluvio-glacial deposits (6%) and fine and medium marine sediments (2%), soils developed from other parent materials occupy a relatively small percentage of the land base.

Soils developed from compact tills generally have 20–65 cm of friable, readily permeable material over the dense subsoil. The subsoils are medium textured, firm to very firm, with bulk densities of > 1.75 g/cm^3, drainable porosity of $< 5\%$, and saturated hydraulic conductivity of < 0.2 m/day. The productivity of these soils is limited by problems associated with dense subsoil and shallowness of top soil. The efficiency of under-drainage is usually curtailed by the slowness of water movement. The use of well-timed secondary drainage treatments, together with under-drainage, is highly recommended to rectify the excessive wetness problems. Because of the undulating to rolling topography and limited vertical water movement, soil erosion by water is a major problem.

Soils developed on loose till generally have more than 100 cm of friable materials. The subsoils are largely single grained, loose to friable, with bulk density of 1.3–1.7 g/cm^3, drainable porosity of 5–25%, and saturated hydraulic conductivity of 0.5–5 m per day. Unlike the soils derived from dense basal till, wetness problems may be readily corrected by under-drainage systems. However, because of the unfavorable topographic conditions, soil conservation measures are needed for lands with slopes greater than 5%, particularly if the lands are under row crops. It is

[1]Soil resource inventory conducted by the Land Resource Research Institute.

estimated that over 46% of these lands have slopes greater than 5%.

SENATOR HERVÉ J. MICHAUD EXPERIMENTAL FARM BUCTOUCHE, NEW BRUNSWICK

Field beans. Over a 4-yr period, Pinto 114 (a colored bean) and Fleetwood (a navy type) were the highest yielding cultivars (2952 and 2627 kg/ha respectively), but maturity was somewhat late (118 and 123 days). Emerson (a large white bean) had good quality and yields (2477 kg/ha), as well as an early maturity (115 days). The cultivar Kenearly (a yellow-eye bean) matured earlier than Emerson and had high quality but low yield (1850 kg/ha).

Onions. Most onions in the Atlantic Provinces are planted from sets. A 2-yr study showed that the optimum size of sets varies from 12 to 20 mm. With smaller bulbs, the yield is low because the onions do not mature. When bulbs larger than 20 mm are used, an excess of bolting is observed. This results in a reduction of Canada No. 1 bulbs.

Rhubarb. A consumer preference test was conducted on five samples of rhubarb prepared in compote from rhubarb that had been frozen for 2 mo. Consumers regard the cultivars Canada Red, Sunrise, and Valentine as interchangeable. MacDonald and Ruby Red were less accepted because of their sourness and color. On the basis of a 3-yr study, the cultivar Valentine had the highest yield and the best quality at harvest.

Raspberry. Red raspberry cultivars have been cropped for a third consecutive year. Of these, Festival has performed best, achieving cumulative yields from 6.7 to 42% higher than other cultivars. Festival produces excellent quality berries on hardy canes. It is the first productive raspberry cultivar for the fresh market found to be adaptable to this area.

Strawberry. Four consecutive years of strawberry cultivar evaluation have shown Kent to be the highest yielding cultivar, with a mean marketable yield from 24.1 to 73.2% higher than the yields of other cultivars tested. A total of 23 cultivars were tested during the 4-yr period. Other cultivars tested and found promising include Cornwallis and Annapolis, two red stele resistant varieties, and Blomidon, a late maturing variety.

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Quebec Region
Région du Québec

J.-J. Jasmin

P.P. Lukosevicius

R. Boulanger

Director General *Directeur général*	J.-J. Jasmin, BSc(Agr), MSc
Program Specialist *Spécialiste en programmes*	P.P. Lukosevicius, MSc, PhD
Chief, Administration Section *Chef de la Section de l'administration*	R. Boulanger, L Sces Adm, AdmA

PRÉFACE

La région du Québec, créée en 1978, comprend quatre stations de recherches, trois fermes expérimentales et cinq sous-stations qui desservent l'agriculture du Québec. En 1984, la région avait un budget de 49 millions de dollars qui ont été employés pour réaliser ses programmes en mobilisant quelque 400 personnes dont 96 chercheurs.

Les activités reliées à l'inventaire et à l'évaluation des sols visaient à approfondir les connaissances en vue de rationaliser l'utilisation des engrais azotés. On s'est aussi attaché à déterminer les besoins des plantes fourragères et céréalières au niveau de la fertilisation minérale en fonction du pH des sols et des régimes hydriques. On a aussi évalué le niveau d'érosion qui affecte les différents types de sols de l'Estrie.

Les objectifs du programme en énergie visaient à établir une relation coût/bénéfice sur l'usage de deux souches de *Rhizobium meliloti*, à caractériser les dommages physiologiques dus au stress hydrique et le métabolisme d'assimilation de l'azote chez *Rhizobium* et à déterminer les principales espèces de champignons endomycorhizateurs spécifiques à la luzerne et au blé.

Le programme de recherches en industrie bovine a visé à améliorer le taux de reproduction des vaches allaitantes, à déterminer les meilleurs croisements génétiques pour la performance des vaches allaitantes et des veaux d'embouche dans les conditions du Québec et à améliorer l'alimentation des bouvillons de marché. Nous avons continué à collaborer au projet national d'amélioration génétique de la vache laitière. Les travaux de recherches sur le porc ont consisté à évaluer la capacité de reproduction des truies qui ont des ovaires anatomiquement différents; nos travaux sur le comportement des porcelets placés dans des conditions spécifiques d'élevage se sont continués. La performance de moutons DLS à la quatrième génération a été évaluée par certaines études des carcasses et des toisons.

Le programme de recherches appliquées aux céréales visait entre autres à déterminer le seuil de rentabilité économique d'une seule pulvérisation contre la pyrale du maïs et à évaluer la sensibilité au complexe *Pyrale-Fusarium-Kabatiella* d'hybrides de maïs commerciaux homologués. La diversification de nos efforts de recherches s'est poursuivie avec l'amélioration du blé et du triticale, en plus de l'orge et de l'avoine et avec la mise au point de cultivars à rendement supérieur et résistant aux maladies les plus importantes.

Le programme de recherches sur les cultures fourragères visait surtout l'amélioration de la luzerne par l'obtention de génotypes supérieurs résistant aux organismes qui causent la pourriture racinaire et la flétrissure verticillienne. Nous avons fait des progrès dans la détermination de la régie du dactyle et de la fléole des prés en association avec la luzerne.

Les objectifs de la recherche sur les cultures maraîchères portaient notamment sur l'amélioration des crucifères, notamment la résistance à la hernie. On peut noter des progrès sur la lutte intégrée de la mouche de la carotte et l'évaluation des cultivars de pois, de fèves verte et jaune, de maïs sucré, d'asperges et d'oignons jaunes et blancs.

La recherche sur les petits fruits est dirigée, entre autres, vers la production de cultivars de fraises aptes à la conservation et à la récolte mécanique; un projet de sélection de framboisiers remontants a débuté. Les travaux de recherches sur les fruits de vergers ont pour but l'amélioration et la fertilisation des pommiers ainsi que leur protection contre les principaux ravageurs. Le projet d'amélioration des pommiers en vue de la résistance à la tavelure a été abandonné. Par ailleurs, on tente de rendre des plantes ornementales plus rustiques sur un réseau de neuf sites à travers la province. Quant aux travaux sur les fines herbes, ils consistent essentiellement à évaluer des cultivars.

La recherche dans le domaine de la technologie de transformation des aliments porte sur les viandes et leurs modes de conservation.

Au niveau du personnel, en 1984, il faut souligner le départ d'Yvon Martel comme directeur de la station de Lennoxville et son remplacement par Jean-Claude Saint-Pierre.

Quant aux réalisations de construction, le personnel de la station de Saint-Jean est entré dans ses nouveaux locaux le 5 septembre 1984.

On peut obtenir de plus amples renseignements sur nos programmes en s'adressant au bureau régional du Québec, Direction générale de la Recherche, Agriculture Canada, Complexe Guy Favreau, 200 boul. Dorchester ouest, Tour Est—Suite 1002-R, Montréal, (Qc), H2Z 1Y3.

J.-J. Jasmin
Directeur général

PREFACE

The Quebec Region, created in 1978, consists of four research stations, three experimental farms, and five substations, which serve Quebec agriculture. In 1984 the region had a budget of $49 million and a staff of some 400 people (including 96 research scientists), which enabled it to carry out its programs.

The purpose of soil inventory and evaluation was to obtain additional information with a view to rationalizing the use of nitrogen fertilizers. Efforts were also made to determine the mineral fertilization requirements of forage and cereal crops, based on the pH and moisture status of the soil. The amount of erosion affecting the various types of soils in the Eastern Townships was also evaluated.

The objectives of the energy program were to establish a cost–benefit ratio for the use of two strains of *Rhizobium meliloti*, to characterize physiological injury due to moisture stress and the metabolism of nitrogen assimilation in *Rhizobium*, and to determine the main species of endomycorrhizal fungi specific to alfalfa and wheat.

The beef industry research program was geared to improving the reproductive rate of nursing cows, determining the breeding crosses that produce the best performance in nursing cows and slaughter calves under Quebec's conditions, and improving the nutrition of market steers. We continued to participate in the national dairy cattle breeding program. The reproductive potential of sows with anatomically different ovaries was the focus of research work on swine. Our research on the behavior of piglets placed in specific production conditions continued. The performance of fourth-generation DLS sheep was evaluated in studies of carcasses and fleece.

The objectives of the cereal research program were to determine the economic profitability of a single spraying for the European corn borer and evaluate susceptibility of licensed commercial corn hybrids to the borer–*Fusarium*–*Kabatiella* complex. The diversification of our research efforts continued with breeding work on wheat, triticale, barley, and oats and the development of higher-yielding cultivars resistant to major diseases.

The forage crop research program centered mainly on alfalfa breeding. Superior genotypes resistant to organisms that cause root rot and verticillium wilt were obtained. Progress was realized in the management of orchard grass and timothy mixed with alfalfa.

The vegetable crop research program focused primarily on the breeding of cole crops, especially for resistance to clubroot. Progress was made in the integrated control of the carrot weevil and the evaluation of cultivars of peas, green beans, wax beans, sweet corn, asparagus, and yellow and white onions.

Small fruit research is centered, among other things, on the production of strawberry cultivars suitable for storage and mechanical harvesting. A project for the selection of remontant raspberries was initiated. Tree fruit research work focused on tree breeding, fertilization, and protection against major pests. The breeding of apples for scab resistance was abandoned. In nine sites throughout the province, efforts were made to produce hardier ornamentals. Herb research centered on the evaluation of cultivars.

Research on food storage technology was concerned with meats and their methods of storage.

Jean-Claude Saint-Pierre took over from Yvon Martel in 1984 as Director of the Lennoxville Research Station. The employees of the Saint-Jean Research Station began working at their new premises on 5 September 1984.

Additional information on our programs may be obtained by contacting the Quebec Regional Office, Research Branch, Agriculture Canada, Guy Favreau Complex, East Tower, 200 Dorchester Blvd. West, Suite 1002-R, Montreal, Quebec H2Z 1Y3.

J.-J. Jasmin
Director General

Centre de recherches alimentaires, Saint-Hyacinthe, Québec

CADRES PROFESSIONNELS

R.R. Riel, BScA, MSc, PhD	Directeur

Biotechnologie

F. Cormier, BSc, MSc, PhD	Culture de tissus
B. Lee, BSc, MSc, PhD	Génie génétique
A. Morin,[1] BSc, MSc, PhD	Enzymologie

Produits laitiers

J. Rolland,[1] BScA, MSc, PhD	Chef de section
D. Roy,[2] BSc(Vivres), MSc	
D. St-Gelais,[1,2] BSc, MSc	

Produits carnés

P. Delaquis,[1,2] BSc, MSc	
C. Zarkadas, BSc, MSc, PhD	Biochimie musculaire

Génie alimentaire

C. Passey,[1] BE, ME, DSc, MBA	Chef de section
C. Toupin,[2] BSc(Vivres)	Transferts thermiques

Fruits et légumes

A. Bégin,[1,2] BSc(Vivres), MSc
G. Doyon,[1,2] BSc(Vivres), MSc
K. Lapsley,[1,2] BSc, MSc

Extraction

S. Gauthier, BSc, MSc, PhD	Protéines végétales

[1]Recruté en 1984.
[2]En congé de formation au doctorat.

INTRODUCTION

Le Centre de recherches alimentaires de Saint-Hyacinthe est encore au stade d'établissement et l'achèvement des travaux est prévu pour 1986. Au cours de l'année, le nombre de cadres est passé de 7 à 15, mais 9 d'entre eux sont en congé de formation et 3 sont affectés au projet de construction. Seulement trois chercheurs dont le lieu de travail est soit l'université Laval, soit McGill (college MacDonald) soit du Québec (Cresala) effectuent présentement des travaux scientifiques. L'un d'eux a donné une série de huit conférences sur la technologie alimentaire à l'invitation de l'Institut supérieur de la science et de la technologie de la Corée. De plus, six autres communications furent présentées à des congrès annuels de sociétés scientifiques au Canada et aux États-Unis.

R.R. Riel
Directeur

VIANDES

Ayant déjà démontré que les lactobacilles sont des agents qui produisent des composés sulfurés volatils comme l'hydrogène sulfuré, on a poursuivi la recherche des facteurs responsables de cette production, soit le pH, l'oxygène et la cystéine. Les principaux constituants identifiés furent le diméthylsulfure et le propanethiol. On s'applique maintenant à vérifier l'hypothèse de la relation de cause à effet de ces substances avec la décoloration verdâtre et les odeurs sulfurées des viandes gâtées sous condition anaérobie ainsi qu'avec les odeurs d'ail et les mauvais goûts produits par les lactobacilles au cours de la maturation des fromages. La méthodologie accélérée qui fut développée pour déterminer les acides aminés basiques dans les viandes a été complétée pour inclure également un certain nombre de composés associés et elle a été appliquée à l'analyse de protéines et d'hydrolysats de tissus musculaires. On a démontré que cette méthode est sûre et efficace. Dans le but d'étudier la possibilité d'établir des normes légales sur la teneur des produits carnés en protéines musculaires, une étude est en cours sur la teneur des tissus en acides aminés basiques.

Une autre méthode a été développée pour la mesure du tryptophane, de la lysinoalanine et des arginines. Cette méthode a été appliquée à l'évaluation de divers tissus animaux et de protéines musculaires.

Étant donné que la lysinoalanine est un constituant toxique qui peut se développer au cours de traitements trop alcalins, son dépistage dans les aliments revêt un intérêt particulier.

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Station de recherches, Lennoxville, Québec

CADRES PROFESSIONNELS

Administration

J.C. St-Pierre, BSc(Agr), MSc, PhD	Directeur
J. de Léséleuc	Services administratifs
D. Savage,[1] BSc(Agr)	Gérant de ferme

Soutien scientifique

A. Belleau	Informatique
S. Gagné-Giguère,[2] BA, MA, MBibl	Bibliothèque

Production de viande

M.H. Fahmy, BSc(Agr), MSc, PhD	Chef d'objectif génétique—moutons
A.M.B. de Passillé, BSc, MSc	Éthologie—porcs
J. Bernier,[3] BSc(Agr), MSc	Régie—boeufs
C. Farmer,[4] BSc(Agr), MSc	Régie—porcs
P.M. Flipot, BSc(Agr), MSc, PhD	Nutrition—bovins de boucherie
J.G. Lussier,[5] BSc, DMV, MSc	Santé et reproduction animales
J.J. Matte,[6] BSc(Agr), MSc, PhD	Nutrition—porcs
S. Pommier, BSc, MSc, PhD	Qualité des viandes—bovins, porcs, moutons

Production laitière

G.L. Roy, BSA, MSc, PhD	Chef d'objectif; génétique—bovins
J. Chiquette,[7] BSc(Agr), MSc	Microbiologie du rumen
C.L. Girard,[8] BSc(Agr), MSc, PhD	Nutrition—jeunes ruminants
L.A. Guilbault, BSc, MSc, DEA (Nutr), PhD	Physiologie de la reproduction—bovins
B. Lachance, BSc(Agr), MSc	Nutrition—jeunes ruminants
H. Lapierre,[9] BA, MSc	Physiologie et nutrition
G. Pelletier, BSc,(Agr), MSc, PhD	Physiologie de la digestion—bovins
D. Petitclerc, BSc, BSc(Agr), MSc, PhD	Physiologie de la lactation—bovins
N. St-Pierre,[10] BSc(Agr), MSc	Analyse de systèmes
C. Vinet,[11] BSc(Agr), MSc	Nutrition—bovins laitiers

Production fourragère et sols

J.-L. Dionne, BA, BSc(Agr), PhD	Chef d'objectif; fertilité des sols
G.M. Barnett, BSc(Agr), MSc	Régie et environnement
C. Fernet, BSc	Amélioration des plantes
W.N. Mason, BSc(Agr), MSc, PhD	Régie et qualité des plantes fourragères
A.R. Pesant, BSc(Agr), MSc	Physique des sols
R. Simard,[12] BSc(Agr), MSc	Fertilité des sols

Départs

J.J. Dufour, BSc(Agr), MSc, PhD	Physiologie de la reproduction—porcs
Y. Martel, BA, BSc(Agr), PhD Promu directeur à la station de recherches de Fredericton, N.B.	Directeur

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[1]Se joint au personnel, avril 1984.
[2]Détachée de la Direction générale des affaires financières et administratives, Division des bibliothèques.
[3]En congé d'études de Ph.D., Université de la Californie, Davis, juin 1983-.
[4]En congé d'études de Ph.D., Université de la Pennsylvanie, septembre 1981-.
[5]En congé d'études de Ph.D., Université de Saskatoon, septembre 1984-. Se joint au personnel, juin 1984.
[6]En congé d'études de Ph.D., National Institute for Research in Dairying, Université de Reading, Angleterre, mai 1984-.
[7]En congé d'études de Ph.D., Université de l'Alberta, mai 1982-.
[8]En congé d'études de Ph.D., National Institute for Research in Dairying, Université de Reading, Angleterre, mai 1984-.
[9]En congé d'études de Ph.D., Université de Sherbrooke, avril 1984-. Se joint au personnel, avril 1984.
[10]En congé d'études de Ph.D., Université de l'Ohio, août 1981-.
[11]En congé d'études de Ph.D., Université de l'Ohio, août 1981-.
[12]En congé d'études de Ph.D., Université de Guelph, juin 1983-.

INTRODUCTION

Les travaux de la station de recherches de Lennoxville visent en partie la solution des problèmes importants dans les productions laitière, bovine, porcine et ovine, les plantes fourragères et les sols. Des recherches de base et appliquées veulent également augmenter l'efficacité des productions animales et partant, leur rentabilité. Pour augmenter les possibilités de recherche de la station, un nouvel édifice de bureaux et laboratoires, offrant le triple de l'espace de l'ancien, a été mis en chantier au cours de l'année 1984. On prévoit qu'on pourra y aménager au début de l'année 1986.

On peut obtenir des renseignements plus complets en écrivant directement aux chercheurs à l'adresse suivante: Station de recherches, Agriculture Canada, C.P. 90, Lennoxville (Québec), J1M 1Z3.

Jean-Claude St-Pierre
Directeur

PRODUCTION ANIMALE

Bovins laitiers

Influence du système fourrager, de la saison et du stade de lactation sur certains paramètres sanguins chez les vaches laitières. L'objectif du cette étude était de déterminer l'influence du système fourrager, de la saison et du stade de lactation sur les valeurs des paramètres du profil métabolique chez des groupes homogènes de vaches. Quarante vaches laitières Holstein de seconde lactation ou plus ont été réparties dans six groupes uniformes et tenant compte de leur rendement en lait, de leur poids corporel et de leur stade de lactation.

Les vaches ont été alimentées selon six systèmes différents: les quatre premiers comportent une saison de pâturage de 130 jours combinée à une saison d'hivernement de 235 jours avec les régimes alimentaires suivants: (1) pâturage de fléole des prés et foin de fléole des prés + trèfle rouge; (2) pâturage de ladino–fléole des prés et foin de fléole des prés + trèfle rouge; (3) pâturage de fléole des prés et ensilage de maïs + 3kg foin/tête/jour; (4) pâturage de ladino–fléole et ensilage de maïs + 3 kg foin/tête/jour. Les deux derniers systèmes comportent une période de stabulation de 365 jours avec les régimes alimentaires suivants: (5) ensilage de maïs + 3 kg foin/tête/jour; (6) ensilage de maïs + ensilage de luzerne et fléole: rapport 1:1.

Les aliments offerts et refusés ainsi que la production laitière ont été pesés quotidiennement pour chaque vache. Des échantillons de sang ont été prélevés en juin, août, septembre et octobre durant la paissance et en novembre, décembre, mars et mai de la période d'hivernage.

Les valeurs de l'hémoglobine et de l'hématocrite ont été plus élevées chez les vaches au pâturage que chez celles gardées en stabulation. En hiver, les valeurs de l'hémoglobine et de l'hématocrite ont été plus faibles chez les vaches recevant de l'ensilage de maïs à volonté (systèmes 3 et 4). L'urémie a été nettement supérieure chez les vaches au pâturage (systèmes 1 et 4) par rapport à celles en stabulation (systèmes 5 et 6). En hiver, les vaches alimentées avec de l'ensilage de maïs ont présenté une valeur moyenne d'urée sanguine nettement plus faible que les vaches assignées aux autres traitements. Des corrélations significatives ont été observées entre la consommation de protéines brutes et l'hémoglobine, l'hématocrite et l'urée sanguine. Les systèmes d'alimentation n'ont pas eu d'influence sur l'albumine sérique en été, tandis qu'en hiver, les vaches alimentées selon le système 5 ont présenté une albuminémie moyenne plus élevée. Une diminution des valeurs de l'hémoglobine, de l'hématocrite et de l'albumine peut être un reflet d'une déficience prolongée en protéines. Les autres fractions protéiniques du sérum de ces vaches n'ont pas varié selon les systèmes d'alimentation et les saisons, à l'exception des bêta-globulines.

Les systèmes fourragers, au cours de l'hivernage, n'ont pas eu d'influence sur la glycémie des vaches. Par ailleurs, le glucose sérique des vaches au pâturage a été supérieur par rapport à celui des vaches gardées en stabulation à l'année. La glycémie des vaches recevant la ration totale mélangée a été plus élevée en hiver qu'en été. Une glycémie plus élevée serait le résultat d'une plus grande consommation et/ou d'une utilisation d'énergie de la ration. Les niveaux sériques de calcium, de phosphore inorganique, de sodium et de potassium n'ont pas été influencés par le système fourrager ou la saison malgré des variations considérables dans les consommations de calcium et de phosphore. Les systèmes de contrôle métabolique de l'animal semblent efficaces pour maintenir des niveaux sanguins constants de ces

minéraux. Par ailleurs, le magnésium sérique est plus faible chez les vaches recevant de l'ensilage de maïs.

Les paramètres sanguins chez les vaches laitières peuvent assez bien refléter l'état nutritionnel en protéines et en énergie, mais sont de pauvres indicateurs de la nutrition minérale des animaux.

Population de follicules chez la vache laitière tôt en phase post-partum. Douze vaches laitières Holstein ont été abattues à 15, 25 ou 35 jours après leur quatrième vêlage. Leurs ovaires ont été immédiatement récoltés et fixés pour des études microscopiques. Les follicules antraux sains et atrétiques ont été mesurés et séparés en six classes d'après leur diamètre. Le nombre de follicules dans chacune des classes a été exprimé en pourcentage du total de chaque ovaire. Les follicules sains de diamètre 0,16 à 0,28 mm sont passés de 27,5 % au jour 15 à 1,5 % au jour 35 tandis que ceux de 0,28 à 0,67 mm et de 0,68 à 1,57 mm de diamètre augmentaient respectivement de 37,4 à 47,2 % et de 11,2 à 17,3 %. On n'a observé aucun changement dans le pourcentage de follicules mesurant 1,58 à 3,68, 3,69 à 8,56 et plus de 8,56 mm. Les follicules atrétiques de 0,29 à 3,68 mm variaient significativement en nombre selon l'intervalle post-partum et/ou s'ils provenaient de l'ovaire qui avait été le porteur du corpus lutéum de la gestation. Les follicules de taille moyenne sont les plus sensibles à tout changement tandis que les gros follicules ne sont pas aptes à subir des changements. Le corpus lutéum de la gestation et/ou le conceptus ont donc un effet résiduel sur le taux de croissance des follicules antraux, même après le vêlage.

Bovins de boucherie

Utilisation des pâturages par le jeune taurillon de race Holstein. Cette expérience visait à valoriser l'utilisation des fourrages via les pâturages. Nous avons donc utilisé 184 taurillons de race Holstein d'un poids vif moyen de 140 kg. Les animaux ont été répartis en cinq groupes correspondants à cinq régimes alimentaires. Trois groupes (A, B et C) ont été envoyés au pâturage. En plus de l'herbe, les taurillons de chacun des groupes recevaient respectivement et quotidiennement 2 (A), 3 (B) ou 1 (C) kg de concentré commercial début croissance. Deux autres groupes (D et E) étaient confinés à l'intérieur et recevaient en plus de l'ensilage d'herbe 1 kg de concentré par jour (D) ou le concentré à volonté (E). L'expérience a duré 134 jours. Les gains de poids quotidiens des taurillons au pâturage étaient de 600, 775 et 830 g pour les animaux recevant respectivement 1, 2 et 3 kg de concentré et de 435 et 1 210 g pour ceux confinés à l'intérieur, groupes D et E. La consommation de matière sèche par jour en incluant les concentrés était de 5,49, 5,06, 6,93, 4,76 et 6,28 pour les traitements respectifs C, A, B, D et E. L'efficacité alimentaire (kilogramme de nourriture par kilogramme de gain) était de 5,49, 5,06, 6,93, 4,76 et 6,28 pour les traitements C, A, B, D et E. Le gain de poids quotidien n'était pas significativement différent entre les animaux du groupe C et ceux du groupe D. Le taux optimal de concentré à utiliser pour les taurillons au pâturage se situe à environ 2 kg par jour, et ce, en fonction des pâturages utilisés dans notre expérience. D'après nos résultats, il est donc possible d'élever des jeunes taurillons de race Holstein au pâturage.

Porc

Croissance, efficacité alimentaire, paramètres sanguins et évaluation des carcasses de cochettes de races Hampshire et Yorkshire abattues à trois âges différents et alimentées sous deux régimes. On a mené une expérience sur 48 cochettes, dont 24 de race Hampshire et 24 de race Yorkshire, dans le but d'étudier l'effet de l'âge et des régimes sur différents paramètres zootechniques. La moitié des cochettes de chacune des races a été alimentée à volonté avec une ration contenant 16 % de protéines (HE) et l'autre moitié recevait 70 % de la consommation du groupe HE (ME). La ration du groupe ME contenait 30 % plus de protéines, de minéraux et de vitamines que la ration du groupe HE. Les animaux ont été abattus à 105, 140 ou 175 jours d'âge. Les échantillons de sang ont été prélevés à l'abattage. Selon nos résultats, les cochettes du groupe ME ont eu une croissance inférieure à celle du groupe HE. Le taux de diminution de croissance correspondait au taux de diminution de la consommation. L'efficacité alimentaire n'a pas été influencée par les niveaux de consommation. Le facteur race n'a pas altéré les coefficients de digestibilité apparente de la matière sèche et de l'énergie. Par contre, ces coefficients ont été plus élevés pour les cochettes du groupe HE que pour celles du groupe ME. L'âge a aussi influencé ces coefficients. L'azote uréique ainsi que le magnésium sanguin ont été influencés par les races. L'azote uréique a été aussi influencé par le régime alimentaire. L'âge des animaux a eu un effet sur les taux d'albumine, de magnésium et de lacto-déshydrogénase et aussi sur la composition des carcasses. Les pourcentages de rendement, de muscle et d'os ont augmenté avec l'âge. Il en a été de même pour l'épaisseur du gras dorsal.

Présence de trois types morphologiques d'ovaires avec différentes populations de fol-

licules chez des cochettes de races Hampshire et Yorkshire. L'observation macroscopique de coupes transversales d'ovaires montés en série nous a permis de mettre en évidence trois types morphologiques en période prépubertaire. Le premier se caractérise par un nombre moyen de follicules de grande taille qui, en formant chacun une protubérance en surface de l'ovaire, lui donne une forme dite «grappe de raisin». Dans ce cas, le nombre de follicules de petite taille est peu élevé. Le deuxième se caractérise par un nombre très grand de follicules de petite taille et un nombre moyen de follicules de grande taille qui, en étant enfouis dans le stroma de l'ovaire, lui donne une forme dite «nid-d'abeille». Enfin on retrouve un type «intermédiaire» lorsqu'aucune des deux définitions précédentes ne peut s'appliquer. Pour l'ensemble des deux races, 28, 47 et 25 % des ovaires observés à 140 et 175 jours d'âge étaient de type «grappe de raisin», «intermédiaire» et «nid-d'abeille» respectivement. Le nombre moyen de follicules atrétiques et non-atrétiques de la classe 0,63 – 1,12 mm et de la classe 1,12 – 2,00 mm était plus élevé dans les ovaires «nid-d'abeille» que dans les deux autres ($P<0,001$). Les cochettes de race Hampshire avec les ovaires «nid-d'abeille» et «intermédiaire» avaient un plus grand nombre moyen de follicules non-atrétiques de la classe 0,63 – 1,12 mm et de follicules atrétiques de la classe 1,13 – 2,00 mm que les cochettes de race Yorkshire (race X types d'ovaires; $P<0,001$). Le nombre moyen de follicules atrétiques et non-atrétiques de grande taille (2,01 – 3,56 mm) et (3,57 – 5,70 mm) était plus élevé dans les ovaires «grappe de raisin» que dans les deux autres ($P<0,001$). Les cochettes de race Hampshire avec des ovaires «grappe de raisin» avaient un plus grand nombre de follicules atrétiques et non-atrétiques de la classe 3,57 – 5,70 mm que les cochettes de race Yorkshire (race X types d'ovaires; $P<0,001$). Ces données nous permettent de conclure que des différences importantes entre races sont rencontrées lorsque les ovaires sont classés d'après leur type morphologique.

Développement folliculaire en période prépubertaire chez les cochettes de races Hampshire et Yorkshire élevées à un rythme accéléré ou modéré de croissance. On a comparé le développement folliculaire de 48 cochettes de race Hampshire ou Yorkshire élevées à un rythme accéléré ou modéré de croissance. Grâce à la technique histologique, les dénombrements de follicules présents sur l'ovaire gauche monté en coupe sériée ont été effectués à 105, 140 et 176 jours d'âge. Tous les follicules antraux ont été alors classés d'après leur diamètre en six catégories et chaque follicule qualifié non-atrétique ou atrétique (cinq picnoses et plus par coupe). Chaque catégorie de follicules a été exprimée en pourcentage du nombre total de follicules présents sur l'ovaire. Le pourcentage de follicules non-atrétiques appartenant à la première classe (diamètre 0,19 – 0,36 mm) était plus élevé chez les cochettes de race Hampshire que chez les cochettes de race Yorkshire à 105 jours d'âge (65,4 vs 47,6 %; $P<0,05$). Les follicules non-atrétiques de la troisième (0,63 – 1,12 mm), quatrième (1,13 – 2,00 mm) et cinquième (2,01 – 3,56 mm) classes ont augmenté chez les deux races entre les jours 105 et 140 de 4,6 à 14,9 %, de 1,8 à 7,0 % et de 0,8 à 2,0 % respectivement ($P<0,05$). La proportion de follicules atrétiques par rapport au nombre total de follicules présents dans l'ovaire, était plus élevée chez les cochettes de race Yorkshire à 175 jours qu'à 140 et 105 jours (38,6 vs 21,9 vs 11,6 % respectivement; $P<0,05$) alors que pour les cochettes de race Hampshire des différences significatives étaient observées entre les jours 140 et 105 seulement (25,2 vs 3,9 % respectivement; $P<0,05$). Les follicules atrétiques de la troisième et quatrième classes ont augmenté respectivement de 2,3 et 1,9 % à 105 jours d'âge à 9,2 et 7,2 % à 140 jours d'âge et à 11,8 et 14,2 % à 175 jours d'âge. La croissance modérée: imposée durant l'ensemble de la période prépubertaire étudiée diminuait le pourcentage de follicules non-atrétiques de la troisième et quatrième classes des cochettes de race Yorkshire de 14,4 et 7,2 % à 9,7 et 4,0 % respectivement ($P<0,05$). Ces données nous permettent de conclure qu'en période prépubertaire le développement folliculaire est plus lent chez les cochettes de race Hampshire que chez celles de race Yorkshire.

Comparaison du stade de développement du tube digestif des plus petits et des plus gros porcelets d'une portée. Le but de cette étude était de déterminer si à 21 jours d'âge les plus gros porcelets allaient plus souvent à la mangeoire et avaient un tube digestif mieux développé que les plus petits porcelets d'une même portée. Le poids des organes, le poids vif et les paramètres biochimiques ont été mesurés à 21 jours d'âge, sur les deux plus gros et les deux plus petits porcelets de chacune des neuf portées étudiées. Le comportement (fréquence et durée de présence) à la mangeoire a été observé à partir du premier jour où les porcelets recevaient de la moulée, c'est-à-dire à 10 jours d'âge, jusqu'à l'abattage. Les tissus et les organes ont été prélevés immédiatement après l'abattage qui avait lieu à 21 jours, après un jeûne de 16 heures. On a mesuré les paramètres biochimiques suivants: les protéines totales, l'acide

désoxyribonucléique (ADN) et l'acide ribonucléique (ARN) du pancréas, de l'estomac et du duodénum ainsi que les activités des enzymes digestives telles l'amylase, la chymotrypsine, la pepsine et la maltase.

Les résultats ont démontré un manque d'intérêt marqué pour la moulée de la part de tous les porcelets. Le pancréas, l'estomac et le duodénum des plus gros porcelets étaient plus lourds que ceux des plus petits porcelets. Les cellules du pancréas des plus gros porcelets étaient plus grosses ($P<0,001$) et contenaient plus de chymotrypsine ($P<0,01$). Cependant aucune hypertrophie de l'estomac et du duodénum n'a été observée. De plus, aucune différence n'a été observée dans les activités spécifiques et totales de pepsine et de maltase de même que dans le nombre de cellules des trois organes étudiés.

L'hypertrophie du pancréas et sa concentration plus élevée en chymotrypsine chez les gros porcelets suggèrent que ces derniers seraient mieux équipés pour la digestion des protéines. Il est donc possible que le système digestif des plus gros porcelets d'une portée soit plus développé et que ces porcelets soient plus aptes à s'adapter à un sevrage à 21 jours d'âge.

Moutons

Croissance et caractéristiques des carcasses d'agneaux jumeaux alimentés à base de céréales ou de fourrages. Dans cette étude, nous avons vérifié l'effet de rang chez des agneaux de souche génétique différente et alimentés avec des rations énergétiquement différentes. Nous voulions vérifier la présence de l'interaction génétique / rations. Cette étude a été réalisée à l'aide de 81 paires de jumeaux issus de croisements entre des béliers de race Suffolk et des brebis de race DLS, Finnoise ou de croisements DLS × Finnois (variant de ⅛ à ⅞ Finnois). Un jumeau était alimenté à base de céréale plus ¼ kg d'ensilage d'herbe par jour et l'autre jumeau recevait de l'ensilage d'herbe à volonté plus ¼ kg de céréale par jour. Les agneaux étaient nés en 1981 et 1982 et ils ont été abattus à un poids vif de 32 ± 1 kg ou 41 ± 1 kg. Le taux de gain a été mesuré à partir du sevrage jusqu'au poids de 32 kg et de 32 à 41 kg de poids vif. Sur les carcasses, nous avons évalué 15 différents paramètres. On a opéré une conversion mathématique de femelles en équivalents mâles pour corriger le paramètre sexe. Les résultats, ainsi transformés, ont été analysés à l'intérieur des poids d'abattage. Le modèle utilisé comprenait l'effet du croisement, du traitement alimentaire et de l'interaction croisement / traitement alimentaire. Nous n'avons pas observé d'interactions. Ceci nous indique que, peu importe le croisement ou groupe génétique, les jumeaux des agneaux les plus performants avec la ration céréalière sont aussi les plus performants avec la ration fourragère. La corrélation de rang de Spearman a été calculée entre les paires de jumeaux de tous les groupes génétiques et puis les jumeaux regroupés pour chacun des groupes d'abattage. Les corrélations étaient de 0,49 pour le pourcentage d'épaule par rapport à la carcasse totale, de 0,14 pour le pourcentage de rendement, de 0,29 pour le taux de gain, du sevrage à 32 kg de poids vif. Les corrélations étaient plus ou moins élevées pour le pourcentage de muscle, de gras et d'os à la 12e côte (0,34, 0,35 et 0,29 respectivement) 0,37 pour le gras rénal, 0,38 pour la longueur de la carcasse et 0,33 pour le pourcentage de longe par rapport à la carcasse.

Culture de tissus

Développement «in vitro» du tissu adipeux. La formation de cellules adipeuses dans un système «in vitro» a été étudiée avec des cellules stroma vasculaires (SV) provenant de dépôt inguinal adipeux du rat mâle. Le milieu de culture préalablement mis en contact avec des cellules adipeuses matures (milieu conditionné) et appliqué sur les cellules SV favorise dix fois plus leur développement en cellules adipeuses comparativement à l'effet de l'addition de milieu de culture frais. La mesure des acides gras libres (AGL) dans le milieu de culture conditionné démontre que leur concentration se situe aux environs de 0,3 à 0,4 mM. Cette concentration en AGL est suffisante pour soulever un intérêt face à leur rôle dans l'effet du milieu conditionné sur les cellules SV. Cependant, l'addition de 0,5 mM d'AGL dans du milieu de culture frais ne provoque pas de réponse aussi forte de la part des cellules SV que le milieu de culture conditionné. De plus, l'addition d'albumine bovine au milieu de culture abolit complètement l'effet de l'addition d'AGL mais ne réduit que de 50 % l'effet du milieu conditionné. D'autres expériences démontrent que même si les stéroïdes peuvent induire la conversion des cellules SV en cellules adipeuses, ils ne sont sans doute pas impliqués dans le phénomène de conditionnement. On note que le type de sérum employé comme supplément dans le milieu de culture affecte le développement des cellules SV. Entre le sérum de porc (PS) et le sérum de foetus bovin (FCS), c'est le premier qui favorise le plus la formation des adipocytes. Le phénomène de conditionnement semble cependant être indépendant du type de sérum utilisé, du moins pour le PS et le FCS. L'addition d'AGL au milieu de culture frais contenant du PS ou du FCS démontre que la combinaison AGL–OPS est la plus adipogénique. L'effet des antiprotéases (l'inhibiteur tryptique du soya et la

leupeptine) dans le milieu de culture ne modifie pas la réponse des cellules SV au milieu de culture conditionné. De plus on démontre que la présence des antibiotiques, plus précisément la tylosine, peut diminuer le développement des cellules en adipocytes. Il existe donc une relation étroite entre les adipocytes matures et leurs précurseurs (cellules SV). La possibilité d'un contrôle local du développement adipeux via des hormones peptidiques reste à démontrer.

PRODUCTION VÉGÉTALE ET SOLS

Préparation du sol et traitements aux herbicides en vue de la production d'orge. On a évalué pendant 2 ans des méthodes de préparation de sol et de contrôle de mauvaises herbes à feuilles larges pour une culture d'orge (*Hordeum vulgare* L. cv Champlain). Cette évaluation s'est faite sur l'argile Kamouraska et le loam graveleux Saint-André à La Pocatière. Le semis direct donne un plus faible rendement d'orge que la préparation habituelle (labour d'automne avec hersage au printemps). Les sols préparés en automne ont produit des rendements équivalents à ceux préparés de façon habituelle lorsque le semis a été hâtif. Les rendements ont cependant diminué plus rapidement avec le retard des semis. Le hersage au printemps des sols préparés à l'automne est nécessaire pour produire des rendements équivalents à ceux obtenus dans les sols préparés de façon habituelle. Ceci est attribuable à la forte augmentation des mauvaises herbes causée par le retard des semis sans hersage au printemps ou par la préparation des sols à l'automne. Les méthodes de préparation du sol ont contrôlé plus efficacement la population de mauvaises herbes que les traitements aux herbicides. Le rendement, la grosseur et la densité des grains d'orge ont diminué avec le retard du semis. Les sols semés sans hersage au printemps étaient plus humides et plus froids en surface que les sols préparés de façon habituelle. Les sols préparés en automne avaient tendance à être plus humides en profondeur que les sols semés directement ou les sols hersés au printemps.

Molybdène pour la luzerne. Plusieurs chercheurs ont constaté un accroissement considérable des rendements de luzerne suite à un apport de molybdène au sol, l'assimilabilité de cet élément s'accroissant avec les pH du sol. À la station de recherches de Lennoxville, nous avons déterminé l'effet du molybdène appliqué à raison de 0,0, 0,1 et 0,3 ppm sur l'argile Sainte-Rosalie, le loam Greensboro et le loam sableux Dandy dans lesquels nous avions cultivé de la luzerne dans un environnement de serre. Nous avons ajusté ces sols aux pH de 5,0, 6,5 et 7,5 et nous les avons soumis à trois régimes hydriques, sec, optimum et saturé.

L'apport de molybdène n'a pas augmenté les rendements de luzerne quels que soient le sol, la dose appliquée, le pH ou le régime hydrique. Cependant, la teneur en molybdène de la luzerne a augmenté linéairement avec les doses de molybdène appliquées au sol. Elle a varié de 0,13 à 23,91 ppm pour l'ensemble des six coupes. À la première coupe de luzerne, elle a même atteint 79,80 ppm pour la luzerne cultivée dans le loam Greensboro soumis à un régime hydrique optimum, chaulé à pH 7,5 et recevant du molybdène à raison de 0,3 ppm. Un fourrage dont la teneur dépasse 20 ppm de molybdène peut devenir toxique pour les bestiaux qui le consommeraient. La teneur en molybdène de la luzerne s'est accrue linéairement avec le pH du sol. L'humidité du sol l'a aussi augmentée. La teneur en molybdène échangeable du sol, après l'expérience, s'est accrue avec les doses de molybdène appliquées et avec l'humidité du sol.

Effets de la lumière et de l'obscurité sur les différentes formes de manganèse dans les sols. Sur dix types de sol de la région de l'Estrie, on a étudié l'effet de la lumière et de l'obscurité sur la teneur en manganèse échangeable, réductible et disponible des sols. Dans des fioles coniques, les sols ont été humidifiés à 90 % de leur capacité optimale de rétention en eau et ensuite transférés dans des cabinets de croissance. Un premier groupe d'échantillons a été gardé continuellement à la lumière puis un deuxième groupe à l'obscurité totale tandis qu'un troisième groupe a subi des intervalles de lumière et d'obscurité (moitié lumière/moitié obscurité) et ce pour des périodes s'échelonnant sur un jour, une semaine, deux semaines et trois semaines. Après chaque période, on a dosé les trois formes de manganèse dans le sol.

L'effet de la lumière a fait passer le manganèse de la forme échangeable à la forme réductible. Généralement, la concentration en manganèse échangeable des sols a diminué et celle du manganèse réductible a augmenté proportionnellement à la prolongation de la période d'éclairement. On n'a noté aucune différence significative entre l'obscurité et la lumière pour les concentrations des trois formes de manganèse. Par contre, l'alternance de ces deux facteurs a eu pour effet de diminuer le manganèse réductible et disponible des sols.

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[1]Détaché de la Direction générale des affaires financières et administratives, Division des bibliothèques.
[2]Prêté, Bureau du Sous-ministre adjoint à la Recherche.
[3]Prêté, Région de l'Atlantique, Surintendant intérimaire, Buctouche, N.-B.

INTRODUCTION

La station et ses trois fermes expérimentales consacrent leurs efforts à la solution des problèmes inhérents aux productions fourragères, céréalières, ovines, bovines, horticoles telles la pommme de terre et les arbres fruitiers, ainsi qu'à l'étude des sols. Des efforts sont faits pour réaffecter les ressources humaines et financières dans des domaines prioritaires et productifs.

La construction d'un édifice principal et de bâtiments secondaires à La Pocatière, ainsi que les allocations de fonds spéciaux de capital et d'années/personnes additionnelles pour des emplois temporaires nous ont beaucoup aidés.

Pour de plus amples renseignements, veuillez vous adresser à: Station de recherches, Agriculture Canada, 2560 boulevard Hochelaga, Sainte-Foy, Québec. G1V 2J3.

S.J. Bourget
Directeur

LES PLANTES

Les plantes fourragères

Légumineuses. Sous les conditions de l'est du Canada, la pourriture de la racine et de la couronne causée par les *Fusarium* spp. est probablement la maladie la plus sévère de la luzerne. Une corrélation négative ($r = -0,87$) a été obtenue entre le rendement et le pourcentage d'infection racinaire chez 12 cultivars. Il existe des différences entre les cultivars pour le degré de tolérance à cette maladie. L'évaluation au champ de populations issues de deux cycles de sélection chez quatre cultivars pour la résistance à cette maladie a révélé qu'un certain progrès peut être accompli par la sélection. En moyenne, une diminution de 10 % dans le degré d'infection a été obtenue par cycle de sélection.

Une nouvelle lignée de luzerne et une de trèfle, issues de croisements des meilleurs individus de plusieurs populations sélectionnées en laboratoire puis au champ pour la résistance à la pourriture, ont été formées et leur évaluation en parcelles permettra de connaître leur potentiel réel dans les conditions rigoureuses du Québec.

On en connaît maintenant un peu plus sur la flore bactérienne des racines de la luzerne: la proportion relative des genres, leur évolution dans le temps et leur distribution dans la racine. Chose surprenante, leur nombre est considérable dans les racines d'apparence saine: jusqu'à 10^4 cellules par g de racine.

Graminées. Une étude entreprise en 1981 sur les effets de la compétition intraspécifique à l'intérieur de familles demi-frères d'alpiste roseau a été complétée en 1984. La variabilité génétique associée avec le rendement, la teneur en fibres, mesurée par les techniques ADF et NDF ainsi qu'avec la concentration en protéines, était élevée pour les individus soumis à aucune compétition (plants espacés) et pour ceux soumis à la fois à une compétition intra et inter-familiale. La variabilité génétique était toutefois limitée pour les individus soumis à une compétition uniquement intra-familiale. L'étude permet de recommander l'utilisation de plants espacés pour la sélection d'individus à valeur alimentaire élevée. Toutefois, aucun dispositif ne semble souhaitable pour ce qui est de la sélection d'individus à haut rendement.

Un cycle de sélection pour le rendement et la teneur en fibres (NDF), en utilisant l'analyse de réflection dans le proche infrarouge, a permis de réduire le NDF de 565 g kg^{-1} à 547 g kg^{-1} tout en n'affectant pas le rendement chez l'alpiste roseau lorsque sélectionné et évalué en plants espacés. Cette expérience a permis d'évaluer l'analyse de réflection dans le proche infrarouge sous des conditions de sélection réelles. Cette technologie s'est avérée fort prometteuse pour le développement de cultivars à valeur alimentaire supérieure. La sélection de fléole des prés pour une meilleure valeur alimentaire s'est poursuivie. Sur la base de tests de descendance, trois populations Syn-0 ont été formées. Ces dernières ont été implantées en plein champ pour la production de semences Syn-1.

Une étude sur le comportement de la fléole des prés durant sa phase reproductive a été effectuée en 1982 et en 1983 à La Pocatière. Cette étude qui consistait à récolter périodiquement les épis de trois cultivars de fléole de précocité différente a démontré que le rendement en semence a augmenté progressivement jusqu'à l'obtention d'un rendement optimal (au-delà de 400 kg/ha) qui a été noté 19, 27 et 32 jours après la floraison pour les cultivars hâtif (Champ), intermédiaire (Climax) et tardif (Bounty) respectivement. L'augmentation du rendement en semence a été suivie par une diminution rapide due à l'égrenage; une perte d'au-delà de 50 % de la semence a été notée

2 à 4 jours après l'obtention du rendement optimal chez les trois cultivars. Le pourcentage de germination des caryopses a augmenté avec l'avancement de la maturité de la fléole et a atteint un niveau maximal (90 % et plus) quelques jours avant l'obtention du rendement optimal en semence. Les épis de moins de 4 cm de longueur représentaient, dans l'ensemble, 38 % de tous les épis récoltés, mais ceux-ci ne contribuaient que très peu (moins de 10 %) au rendement total en semence. Le rendement en semence des cultivars a augmenté avec chaque dose croissante d'azote (de 0 à 72 kg/ha de N_2). La densité des épis de plus de 4 cm de longueur avait tendance à accroître avec chaque augmentation de la dose d'azote, mais le nombre total d'épis ne variait que très peu en fonction des doses d'azote.

On a réussi à reproduire la coulure des graminées en laboratoire par une méthode qui simule les agissements d'un insecte piqueur. Lorsqu'inoculé à l'aide de cette méthode, le *Fusarium poae* a infecté le col de l'épi et provoqué les mêmes symptômes qu'on observe au champ. Un essai de lutte avec des pesticides devrait nous permettre de maîtriser cette maladie importante pour la production de semences et de démontrer le rôle prépondérant des insectes comme vecteur du *F. poae*.

Huit cultivars de ray-grass annuels ont été évalués à six stations en 1983 et 1984 pour deux régimes d'exploitation soit pour le foin et le pâturage. Les cultivars Aubade et Maris Ledger se sont révélés les meilleurs sous les deux régimes d'exploitation.

Mélanges fourragers. Un essai a été entrepris à cinq stations agronomiques réparties dans la province afin d'étudier l'effet des doses de semis sur le rendement, la composition botanique et la qualité nutritive de divers cultivars de fléole semés en mélanges avec le trèfle rouge. Les résultats de l'année de l'établissement indiquent que, dans l'ensemble, la proportion de fléole (10 % en moyenne) et le rendement des mélanges (4498 kg/ha en moyenne) récoltés en août ne varient que très peu en fonction des doses de semis de la fléole lorsque celles-ci varient de 3 à 9 kg/ha. Toutefois, le rendement des mélanges trèfle rouge–fléole varie de 4232 à 4730 kg/ha et la proportion de trèfle rouge passe de 80 % à 92 % avec un accroissement de la dose de semis du trèfle rouge de 3 à 9 kg/ha, mais les résultats ne sont pas, dans l'ensemble, statistiquement différents d'une dose de semis du trèfle rouge supérieure à 6 kg/ha. Quelles que soient les doses de semis, les cultivars de fléole Salvo et Climax se sont comportés de façon similaire l'année de l'établissement.

Malherbologie. Les études portant sur la biologie de la spargoute des champs, mauvaise herbe importante dans l'est du Canada, montrent qu'elle est très compétitive en présence d'autres mauvaises herbes et de luzerne. Sa levée hâtive, son abondante production de graines et ses faibles exigences en éléments nutritifs lui ont, entre autres, permis de dominer une population de sétaire glauque.

Les densités de population de la spargoute dans une luzernière en implantation variant de 30 à 2 000 plantes par mètre carré peuvent causer des diminutions de rendement variant de 20 à 90 % à la première coupe de luzerne. Ces diminutions sont cependant beaucoup moins importantes à la deuxième coupe.

La plus grande partie de la biomasse annuelle du chénopode blanc provient des plantes qui ont germé tôt au cours de la saison; les plantes qui germent après la fin juin ne constituent que 10 % de la biomasse totale et ces plantes sont généralement plus sensibles à la mortalité. Le seuil de nuisibilité du chénopode dans la luzerne nouvellement implantée varie de 200 à 800 plantes par mètre carré, dépendant des conditions de croissance qui affectent les deux espèces.

Des études entreprises avec la fléole des prés laissent supposer que les mauvaises herbes peuvent causer des pertes substantielles lors de l'implantation de cette espèce fourragère. Par ailleurs, ces pertes ne seraient pas limitées à la première récolte de fourrage (année d'implantation) mais s'échelonneraient au moins jusqu'à la fin de la première année de production. Les pertes reliées à la présence de mauvaises herbes annuelles à feuilles larges, au cours de la première année, seraient plus élevées que celles reliées à la présence de graminées annuelles au cours de la même période.

Récolte et conservation. Des expériences sur le séchage de la fléole et de la luzerne se sont poursuivies pour une deuxième année à la station de recherches de Deschambault ainsi qu'au département de génie rural de l'Université. On a comparé plusieurs modèles mathématiques pour prédire le séchage. Au laboratoire, on a fabriqué un simulateur de gyrofanage pour estimer les pertes matérielles.

On a fait des observations au champ sur la croissance de la luzerne en fonction du temps. Ces données serviront à valider un modèle de croissance. Le travail de modélisation des chaînes fourragères s'est poursuivi; on estime que les systèmes de foin sont encore satisfaisants sur les petites fermes laitières (40 vaches ou moins) tandis que l'ensilage devient intéressant pour de plus grosses fermes.

Une nouvelle expérience sur les silos-meules a commencé en juin 1984 à Normandin. On a fabriqué trois meules: la première humide et sans traitement, la deuxième humide avec l'ajout d'acide formique et la troisième préfanée au champ pendant environ 6 h sans autre traitement. Ces trois ensilages ainsi que du foin seront servis à des vaches laitières et à des moutons entre novembre 1984 et mars 1985 pour évaluer la performance.

La survivance à l'hiver

Influence du climat. Les légumineuses, les graminées fourragères et les céréales se sont moins bien acclimatées à Saint-Hyacinthe qu'à La Pocatière durant l'automne et l'hiver 1983–84; la tolérance au gel (TL_{50}) a été en général inférieure de 2 à 3 °C à Saint-Hyacinthe, sauf pour les cultivars du seigle, Puma et Cougar. Ces deux cultivars ont atteint respectivement un minimum de −42,5 et −39,8 °C à Saint-Hyacinthe et −35,5 et −32,5 °C à La Pocatière. Après le seigle, les cultivars de la fléole, Engmo et Climax, ont montré la meilleure tolérance au gel à La Pocatière avec une TL_{50} de −35,5 °C, suivis du brome Beacon et Saratoga, −33,1 et −30,9 respectivement, du blé Kharkov et Frédéric, −30,0 et −25,0, du triticale Wintri et GWT-3, −25,5 et −21,6 °C, du trèfle Altaswede et Lakeland, −18,9 et −17,3, et de la luzerne Saranac et Vernal, −18,7 et −17,3 °C. Les céréales se sont endurcies beaucoup plus rapidement que les légumineuses et les graminées fourragères aux deux endroits et ont atteint un maximum de tolérance au gel entre la mi-novembre et la mi-décembre. Le maximum de tolérance au gel pour les cultivars de légumineuses et de graminées fourragères a été atteint pour la plupart au cours de janvier et de février 84. Ces résultats favorisent l'hypothèse d'une levée de dormance plus rapide chez les céréales que chez les légumineuses ou les graminées fourragères, d'où une perte de la tolérance au gel plus rapide également.

Malgré la tolérance au gel moins élevée à Saint-Hyacinthe, toutes les espèces ont survécu à l'hiver grâce à une bonne couche de neige qui maintient la température du sol près du point de congélation au niveau des collets. À La Pocatière, le blé, le seigle et le triticale de même que le trèfle et la luzerne n'ont pas survécu à la formation de glace artificielle au début de décembre 83. Dans les mêmes conditions, le brome a résisté à 70 et 80 %, et la fléole des prés à 90 et 95 %. Dans ces conditions, la température du sol est descendue jusqu'à −11°C. La présence d'une couche de polyuréthane de 2,5 cm d'épaisseur par-dessus la glace a empêché la température du sol de descendre sous les −2 °C, augmentant la survie à l'hiver des légumineuses de 70 à 85 % et celle des céréales de 25 à 50 %. Le gel serait donc la cause première de la mortalité hivernale et non l'asphyxie des racines sous la glace. Plusieurs cycles de gel–dégel poursuivis en cabinets de croissance et en serres de plastique avec des céréales d'hiver augmentent la mortalité de ces espèces. Des cultivars de pommiers ont été également affectés par le gel–dégel et après quatre cycles, deux cultivars avaient péri et un troisième n'a survécu qu'à 60 %. L'emploi de cycles de gel–dégel aurait cependant l'avantage de permettre une meilleure sélection de cultivars résistants au gel dans un programme d'amélioration.

Mécanismes de la résistance au froid. La putrescine et la spermidine, deux polyamines, augmentent dans les feuilles et les collets du blé d'hiver soumis à un endurcissement à 2 °C et cette augmentation est plus importante chez le blé rustique Kharkov que chez le blé sensible Champlain. Après 2 ou 3 jours, la teneur de ces deux polyamines dans les tissus n'augmente plus et demeure stable jusqu'à la fin de l'endurcissement. Après 2 semaines à 2 °C, on observe une diminution très rapide (de 5 à 10 fois) de la putrescine et de la spermidine chez les plantes remises dans des conditions de croissance à 22 °C. D'autres polyamines telles que la spermine et la cadavérine sont aussi présentes, mais en faible quantité, à la limite de la détection, et leur teneur en fonction des variations de la température ne change pas. Des résultats semblables obtenus avec deux cultivars de luzerne, Vernal et Saranac, soumise à un endurcissement au froid, indiquent que la putrescine et la spermidine pourraient avoir un rôle important dans l'acclimatation des plantes au froid et éventuellement servir de marqueurs de la rusticité.

Durant l'acclimatation au froid des légumineuses, des graminées fourragères et des céréales, à La Pocatière et Saint-Hyacinthe, l'augmentation de la proline dans les collets a coïncidé avec celle de la matière sèche, le maximum étant atteint entre la mi-novembre et la mi-décembre. La teneur en sucrose des collets augmente au début de l'hiver chez la plupart des espèces alors que les sucres réducteurs augmentent plutôt à la fin de l'hiver en mars, surtout chez les céréales. Quant aux sucres totaux, l'augmentation varie beaucoup avec les espèces et la teneur maximale ne coïncide pas toujours avec le maximum de tolérance au gel. Des résultats à peu près identiques ont été observés chez deux cultivars de fraisier, Bounty et Red Coats, cultivés à la ferme Chapais de Saint-David.

L'énergie: fixation d'azote et endomycorhizes

Fixation d'azote à basse température. La caractérisation morphologique et physiologique des 48 souches de *Rhizobium* isolées de légumineuses arctiques est maintenant terminée. L'analyse numérique des 74 facteurs mesurés démontre d'une part que cette population de *Rhizobium* diffère des autres espèces connues de *Rhizobium*. D'autre part, la similarité obtenue par cette taxonomie numérique divise la population en 11 groupes, démontrant ainsi une grande diversité dans les isolats. Cette observation est confirmée par les études de l'homologie de l'ADN par chromatographie sur hydroxylapatite qui révèle une étroite association avec des souches types de l'astragale. Le profil des plasmides et des essais de conjugaison avec *R. trifolii*, *R. meliloti* et *R. leguminosarum* indique la possibilité de construction génétique de nouvelles souches en combinant des souches arctiques avec des souches tempérées. Toutes les souches arctiques dans cette étude nodulent le sainfoin, légumineuse tempérée cultivée dans l'Ouest mais aucunement reliée aux légumineuses-hôtes d'où proviennent nos isolats. Les mesures d'efficacité à fixer symbiotiquement l'azote avec le sainfoin démontrent que plusieurs souches arctiques sont égales ou supérieures à celles commercialement utilisées et de sources tempérées. Nous avons aussi trouvé que 40 isolats montrent une activité nitrogénasique ex-planta, caractéristique quelquefois observée chez les souches tropicales.

Métabolisme. Une méthode d'isolement de bactéroïdes de *Rhizobium meliloti* par sédimentation sur gradients de densité de Ficoll permet d'obtenir des bactéroïdes débarrassés de bactéries libres et des composantes de la plante-hôte. Le matériel de départ est un extrait de racines et de nodules de luzerne. Les activités spécifiques de la glutamate déshydrogénase (GDH) et de la glutamate synthase (GOGAT) sont environ les mêmes chez les bactéroïdes et dans le cytosol du nodule, mais dans ce dernier l'activité spécifique de la glutamine synthétase (GS) est 50 fois plus élevée que chez les bactéroïdes. Il est clair que l'ammoniac produit lors de la fixation symbiotique de l'azote chez la luzerne est assimilé via la GS de la plante et la GDH des deux partenaires symbiotiques. Des analyses de la sève par HPLC ont démontré que la fertilisation à l'ammonium (3 mM) provoque une augmentation importante de la concentration en Asp, Asn, Glu et Gln, en comparaison avec des plantes fertilisées au nitrate. Parallèlement, en utilisant des protoplastes isolées à partir de jeunes racines, il a été démontré que l'activité GS est distribuée entre le cytoplasme et les proplastides. Les enzymes provenant des deux sources ont des caractéristiques catalytiques différentes.

Inoculants commerciaux. En collaboration avec la Direction de la production et de l'inspection des aliments dans le cadre de son Programme inoculants des légumineuses, des échantillons d'inoculants commerciaux à base de *Rhizobium* ont été analysés par la méthode officielle d'infection de la plante, et il a été démontré que 78 % des échantillons soumis satisfont aux normes légales. La production d'inoculants concentrés de *Rhizobium* ($>10^{10}$ cellules par mL) sur lactosérum est au stade de transfert de cette technologie vers une firme industrielle. En utilisant une méthode standardisée et répétitive pour la dessiccation des cellules et l'évaluation des dommages, nous avons montré que les *Rhizobium* survivent mieux lorsqu'ils ont été produits sur un milieu contenant du lactosérum plutôt que sur le milieu habituel au mannitol.

Banque de Rhizobium. Nous avons isolé 56 souches de *Rhizobium phaseoli* à partir de haricots (*Phaseolus vulgaris*) adaptés aux conditions tropicales (Rwanda, Afrique). La caractérisation en serres de l'efficacité symbiotique de 30 souches de *R. leguminosarum* avec la féverole (*Vicia faba* var. *minor*, cultivars Ackerperle et Herzfreya) et la gourgane (*Vivia fava* var. *major*, cultivar Baie St-Paul) révèle que chez la féverole 23,3 % des souches sont très efficaces (TE), 10 % efficaces (E) et 16,7 % inefficaces (I), tandis que chez la gourgane 18,5 % sont TE, 74,1 % E et 7,4 % I. Aucune corrélation significative n'a été observée entre les rendements de la gourgane et de la féverole inoculées avec les mêmes souches, indiquant une spécificité différente des souches avec ces plantes. Des essais au champ nous indiquent que les souches autochtones sont aussi compétitives et efficaces que les souches introduites.

Chez le pois (*Pisum sativum* 'Targett'), l'évaluation en serres de 41 souches de *R. leguminosarum* indique des différences dans l'efficacité symbiotique. L'évaluation en serres de l'efficacité symbiotique de fixation de N chez 65 souches de *R. phaseoli* avec le haricot (*Phaseolus vulgaris*, cultivar Goldie) montre que 4 souches sont TE, 56 sont E et 5 sont I. Il existe cependant une régression linéaire entre l'efficacité symbiotique de fixation de N et les rendements en matière sèche. Les essais au champ avec les souches très efficaces indiquent une très forte compétition des souches autochtones.

Endomycorhizes. Des tests d'efficacité de deux espèces de champignons endomycorhiziens VA

ont été effectués sur la luzerne. L'une des deux souches, indigène du Québec, s'avère très prometteuse. Des spores de champignons endomycorhiziens, provenant de luzernières ou de plantes sauvages du Québec, ont été mises en culture monosporale afin de les multiplier pour obtenir de l'inoculum pur. Des cages spéciales ont été mises au point pour la culture semi-aseptique d'espèces pures de champignons endomycorhiziens. Cinq espèces (*Glomus clarum, G. intraradices, G. monosporum, G. versiforme, G. vesiculifer*) ainsi protégées sont utilisées pour la production massive d'inoculum endomycorhizien destiné à tous nos besoins. Au cours d'essais préliminaires, la technique de mesure de l'ATP pour l'évaluation de la biomasse active du mycélium extra- et intraracinaire nous a donné des résultats satisfaisants.

Les céréales

Amélioration. En 1984, la diversification de nos efforts de recherche s'est poursuivie avec l'amélioration du blé et du triticale en plus de l'orge et de l'avoine. Nous visons un partage égal de nos efforts entre ces quatre espèces d'ici 1986. Cette année, 43 % des efforts portaient sur l'orge, 35 % sur l'avoine, 12 % sur le triticale et 11 % sur le blé. Nos objectifs de recherche sur le blé sont reliés à la réalité québécoise, car nous ne produisons que 2 % de notre blé d'alimentation humaine. Nous visons donc un blé panifiable à haut rendement, adapté aux conditions climatiques du Québec et aux régions périphériques de la province par sa hâtivité. Quant au triticale, aucun type printemps n'est recommandé pour culture au Québec; notre objectif est donc un triticale ayant le rendement et la maturité du blé et un poids à l'hectolitre de 70 kg pour en faire une culture attrayante pour l'agriculteur.

L'amélioration de l'avoine continue à produire des génotypes intéressants. Une lignée hâtive à très haut rendement, Q.O. 186.10, fera l'objet d'une demande d'homologation pour remplacer Cabot et Fundy dans les Maritimes. Ce nouveau cultivar est très attendu pour culture en rotation avec la pomme de terre. La hâtivité est très importante pour permettre la récolte des grains avant la récolte principale des pommes de terre. Deux autres lignées d'avoine, également en essais d'homologation, sont très prometteuses par leur rendement et leur résistance au virus de la jaunisse nanisante de l'orge (VJNO). Plusieurs lignées d'orge à paille naine et forte continuent à produire des rendements intéressants.

Pathologie. Les études pathologiques sur les essais d'homologation et de tamisage ont été poursuivies en 1984 pour étudier l'évolution des maladies et la résistance des nouveaux cultivars en essais. Pour diminuer la perte due aux maladies, plus de 1 000 000 de plants d'avoine ont été inoculés au charbon nu et 60 000 plants de blé, à la fusariose de l'épi. Un contrat de recherche pour transférer la résistance à la fusariose à des blés québécois par culture d'anthères a été accordé à l'Université Laval pour une deuxième année. Jusqu'à maintenant, il est permis de penser que les milieux identifiés pour partir et régénérer des cals en plantules vertes sont 10 fois supérieurs aux résultats mentionnés dans les publications.

L'amélioration des méthodes d'hybridation interspécifique permet la production d'hybrides qu'il était impossible d'obtenir auparavant. Ainsi, le blé a été croisé avec trois espèces d'Elymus et trois espèces d'Agropyron pour transférer la résistance au VJNO, à la pourriture nivéale et à la glace. Le programme de croisements interspécifiques a produit jusqu'ici 5 kg de ségrégants pour diverses sélections telles le VJNO et la glace. Dans l'orge, la résistance au VJNO de 700 lignées a été confirmée ce qui prouve l'excellence de l'inoculation artificielle et de la sélection en F_4. L'évaluation des blés et triticales extraits d'essais internationaux a des retombées positives pour le Québec, certains de ces génotypes ont un rendement égal ou supérieur aux témoins québécois avec une maturité relativement hâtive.

Régie. Des études préliminaires de compétition entre la spargoute des champs et l'avoine ont révélé une très forte capacité de compétition de la céréale, car avec 1 500 plantes par mètre carré, le rendement de l'avoine n'a pas été affecté significativement. Par contre, les mêmes études sur le chénopode blanc et l'avoine ont révélé que 800 à 1 000 plantes de chénopode au mètre carré causent des pertes significatives de rendement.

LES SOLS

La fertilité

Efficacité physiologique de l'azote. L'indice de l'efficacité physiologique de l'azote (IEP), considéré comme étant le rapport gramme–grains (gramme d'azote exporté par la plante, grains plus paille) a été étudié en serre sur sept cultivars d'avoine, en fonction des différentes doses d'azote. Le comportement des cultivars a été très différent. Les cultivars à haut rendement, Cascade, Lamar et Laurent, ont eu une teneur (%) en azote beaucoup plus faible que les cultivars à bas rendement, Manic et surtout Elgin. Le IEP a été par contre plus élevé chez les cultivars plus productifs. Ainsi, il a été de 54,9, 50,2 et de 48,6 chez les cultivars Cascade, Laurent et Lamar et de seulement 43,7 et 35,1 chez Manic et Elgin. Mal-

gré le fait que les cultivars Elgin et Cascade ont exporté sensiblement la même quantité d'azote par plante, ce dernier, dû à son IEP plus élevé, a produit un rendement en grain de 55 % supérieur à celui de Elgin.

Les résultats obtenus démontrent que plus l'efficacité physiologique de l'azote est élevée chez un cultivar, plus ses rendements sont élevés pour la même quantité d'azote assimilable. Les rendements moyens des cultivars ont été ainsi peu liés aux quantités totales d'azote exportées, mais significativement correlés à l'IEP ($r = 0,94$). Chez tous les cultivars et surtout chez les cultivars productifs, le IEP a été plus élevé dans les traitements à faible quantité d'azote assimilable et a diminué avec l'augmentation des doses d'azote administrées. Étant donné que l'efficacité physiologique de l'azote est un caractère génétique du cultivar, elle peut être utilisée comme critère important dans le processus de l'amélioration des céréales.

Fertilisation économique. Les recommandations des doses d'engrais sont habituellement basées sur la dose optimum économique de chaque culture, dose qui assure le profit le plus élevé par unité de surface. Quand les quantités d'engrais sont limitées, des doses moindres que l'optimum économique doivent, évidemment, être appliquées. Une méthode a été proposée pour calculer les doses d'engrais pour deux cultures (S_1 et S_2) quand les doses optimum économiques ne peuvent pas être appliquées. Les équations à utiliser dans ce cas sont les suivantes.

$$S_1 = P_2b_2 - P_1b_1 + 2P_2c_2k/2(P_1c_1 + P_2c_2)$$
$$S_2 = k - S_1$$

où S_1 et S_2: les doses d'engrais partagées pour la culture 1 et 2 respectivement, en kg/ha; P_1 et P_2: prix des deux cultures à la vente, en $/kg; b_1, c_1, b_2 et c_2: coefficients de régression du modèle quadratique ($Y = a + bx + cx^2$) utilisé au préalable pour la prédiction des rendements des deux cultures; k: la dose totale d'engrais disponible, moyenne pour 2 ha, à partager chez les deux cultures, en kg/2 ha.

Phosphore et potassium chez la luzerne. Une expérience portant sur l'effet de cinq doses de phosphore et de cinq doses de potassium sur les rendements de cinq cultivars de luzerne a été faite en serre. Le cultivar Apica a le mieux répondu aux apports de phosphore, le rendement de huit coupes passant de 45,6 g/pot pour les témoins à 73,4 g/pot à la dose de 80 ppm de phosphore. Le meilleur rendement a été obtenu avec le cultivar Thor (78,6 g/pot) suite à une fertilisation de 40 ppm de phosphore. Les cultivars Thor et Apica ont le mieux répondu aux apports de potassium, la meilleure dose entraînant des augmentations de rendements de l'ordre de 34 g/pot. En moyenne, pour tous les traitements, Thor a donné les rendements les plus élevés (69,1 g/pot) tandis que Iroquois a donné les rendements les plus faibles (58,7 g/pot).

La physique et la productivité. Des échantillons provenant de quatre horizons de surface et d'un horizon B des sols Kamouraska, de l'Anse, Sainte-Rosalie et Saint-Urbain ont été séchés à l'air et par la méthode du point critique. Avec cette dernière méthode, le volume poreux total était de 19 à 84 % supérieur à celui mesuré dans les échantillons séchés à l'air. L'effet du séchage sur les pores grossiers (>8,8 µm, moyens et petits (<0,19 µm) a été analysé par mesures de porosité au mercure et de densité. Les pores moyens sont les plus sensibles à la méthode de séchage, suivis des pores grossiers et des petits pores. Ces différences ne s'expliquent pas convenablement par un simple retrait. Il apparaît aussi que la matière organique exerce un «effet tampon» sur la réorganisation des particules.

Des échantillons de l'horizon Ap du sol Kamouraska ont été incubés en présence de divers amendements organiques, tourbe, paille, compost et engrais vert, appliqués à un taux de 7,5 t de C/ha. Le taux d'humidité était de 80 % de la capacité au champ. L'incubation a été faite à 37 °C pour des périodes de 4, 8, 16, 32 et 64 semaines. Des tests de tassement ainsi que des mesures de densité apparente et de conductivité hydraulique ont ensuite été effectués. Par rapport au sol non amendé (densité 1,1 g/cm³, K sat = 265 cm/h), on a mesuré des densités variant de 1,02 à 1,12 g/cm³ et des valeurs de K sat généralement inférieures à 150 cm/h. La décomposition des amendements organiques pouvait donc provoquer des agrégats plus stables, puisque la densité était plus faible, mais avec sans doute une structure différente et un système de pores moins organisé que dans le sol de départ.

La chimie et la mise en culture. L'emploi de diagrammes de solubilité construits pour des horizons de surface de sols sableux à argileux présentant des pH de 4,4 à 7,1 et des teneurs en $H_2PO_4^-$ variant de 10^{-6} à 10^{-3} M ont permis de montrer que ces conditions favorisaient la formation d'hydroxyapatite dans la plupart des échantillons. Cependant, des niveaux de P suffisamment élevés associés à des conditions de pH supérieur à 6,5 provoquaient la formation de phosphate dicalcique ou octocalcique moins solubles et donc moins assimilables par la plante. Ce phénomène d'immobilisation de P s'accroît de plus en plus avec les applications massives de fertilisants phosphatés associés au chaulage excessif dans plusieurs exploitations agricoles.

Station de recherches, Sainte-Foy, Québec

Les horizons LH, Ae, Bhf et Bf de deux Podzols échantillonnés sous couvert forestier et utilisés pour des essais de mise en culture présentaient généralement la séquence suivante pour leur contenu en éléments totaux: Fe > Ca > K >> Mg >> Na. Les contenus en K, Ca, Mg et P solubles et échangeables sont de 3 à 12 fois supérieurs dans l'horizon LH comparativement à l'horizon Ae sous-jacent et cette proportion s'accroît avec la profondeur même si les teneurs en éléments totaux demeurent relativement constantes dans toute la séquence d'horizons d'un profil.

La pédogénèse. On a caractérisé un saprolite, ainsi que le sol qui le surmonte, dans la région d'Orford. Les deux matériaux se distinguaient par la nature des minéraux présents, l'illite et la chlorite dans le till, la muscovite et la kaolinite dans le saprolite. La présence de quantités abondantes de kaolinite dans quelques dépôts est un indice intéressant pour caractériser les conditions d'altération qui ont prévalu au Québec.

FERME EXPÉRIMENTALE, LA POCATIÈRE

Les plantes fourragères

Semence du trèfle rouge. Le rendement en semence du trèfle rouge dépend beaucoup de l'efficacité des pollinisateurs naturels. Sous nos conditions, l'utilisation d'abeilles caucassiennes pour augmenter ou suppléer davantage au travail des bourdons ne semble pas tellement efficace. Cet insecte quand il a le choix visite de préférence d'autres plantes que le trèfle rouge. Au cours de la période intense de floraison, la présence de cette abeille est faible. Elle visite le trèfle rouge principalement en fin de saison après que ses plantes préférées ont terminé leur floraison. La présence tardive de l'abeille dans les populations de trèfle rouge presque passées fleurs et son intérêt pour les fleurs plus petites ne contribuent probablement pas tellement à augmenter la quantité de graines viables produites.

Besoins en azote. L'association légumineuse–graminée montre généralement un avantage reciproque à leur production végétative. On pense que le transfert possible d'azote de la légumineuse à la graminée en soit une des causes principales. En plus d'une production végétative augmentée, il semble que cette association favorise également une augmentation de la matière organique et du contenu en azote du sol. L'augmentation de la matière organique semble plus importante que celle de l'azote. Ces deux particularités sont un peu plus accentuées sur le loam St-André que sur l'argile Kamouraska.

Régie du semis. On a constaté que les semis de plantes fourragères dans un tapis végétal, réalisés tardivement au printemps, éprouvent de sérieuses difficultés à s'établir. Comme ils sont encore plus sensibles aux conditions climatiques que les semis habituels, ces semis réalisés tardivement risquent donc beaucoup de subir les effets négatifs d'un manque de précipitation. Le glyphosate, principal herbicide utilisé pour contrôler la végétation adventice et qui pour être efficace doit être appliqué à un stade avancé des plantules, ne permet pas de semer à la date idéale. Les semis ainsi retardés ne permettent pas aux plantules en développement de profiter de l'eau qui se trouve en plus grande quantité dans le sol tôt au printemps. C'est sûrement un facteur important d'échec avec cette méthode de semis. Il faudra vérifier la valeur de nouveaux herbicides pour contourner ce problème de semis tardifs au printemps.

Essais de cultivars. Comme à chaque année, plusieurs lignées et cultivars de différentes espèces fourragères sont évaluées. Leur évaluation a permis d'éliminer des essais les lignées et les cultivars suivants:

Luzerne: CW 62 et CW 69
Fléole: CM 8, FY 10, FS 23 et SS 9
Brome: S-7414, S-9044 et Regar
Dactyle: Orbit, Dart, Hallmark, Kay, Juno OK-WH, OX-1, MLM-14912 et OK-SF-19

Neuf cultivars de ray-grass italien et Westerwold ont été évalués sous des régies de foin et de pâturage. Sous régie de foin en 1983, les cultivars ont rendu 16 % plus d'herbage que les autres graminées. Les cultivars Aubade (Westerwold) et Maris Leds (Italien) ont été en général les meilleurs.

La pomme de terre

Amélioration. L'amélioration génétique de la pomme de terre s'est continuée en 1984, à La Pocatière. Deux cents croisements ont été réalisés. Des lignées produites en 1983 (10 500) ont été évaluées au champ et 9,4 % ont été sélectionnées. Les lignées sélectionnées à La Pocatière en 1983 (1 264) et celles sélectionnées à la station de Frédéricton la même année (991) ont été évaluées sur deux sols (St-André et L'Anse) au stade 4-buttes. La sélection au champ a permis de conserver 29 et 26 % de ces lignées pour les évaluations de rendement, densité relative, cuisson à l'eau et croustille en laboratoire (LP85 en 1985). Les 120 lignées sélectionnées en 1983 (LP84) ont été évaluées pour la première année en parcelles aléatoires sur trois sols différents. L'épuration de

ces lignées et actuellement en cours. Elles ont toutes été vérifiées pour la présence du viroïde de la filosité et de la bactérie du flétrissement bactérien. Toutes ces lignées ainsi que les autres sélections LP du programme répondaient négativement à ces deux tests. Pour la première fois, un essai de tamisage a eu lieu sur trois stations: Lennoxville, Normandin et La Pocatière. Cet essai était composé de deux lignées LP81 qui n'avaient pas encore été évaluées dans le réseau d'essai provincial et de 10 LP82 et 21 LP83. La sélection de ces lignées d'après les tests de laboratoire et les analyses statistiques permettront d'inclure les meilleures lignées dans le réseau d'évaluation provincial en 1985. Ces lignées ont été épurées en collaboration avec le centre de certification et d'épuration de la pomme de terre et elles sont multipliées en serre pour les essais régionaux de 1985.

Dans le réseau d'essais régionaux 5 LP80 et 11 LP81 ont été évaluées. Le nombre de lignées évaluées en essais régionaux était de 237.

Parcelles de démonstration. Des parcelles de démonstration ont été faites en collaboration avec le centre de certification et d'épuration de la pomme de terre avec tous les cultivars homologués au Canada et ailleurs, et certaines lignées adaptées aux conditions du Québec. Les parcelles servaient à l'entraînement des élagueurs et de professionnels à reconnaître les cultivars.

Les arbres fruitiers. Toutes les variétés ou lignées de pruniers ont produit en 1985 dont plusieurs pour la première fois depuis la plantation en 1977. La variété Veeblue (V33028) a produit 25,4 kg/arbre de prunes de bonne qualité. Cette même variété planté en 1975 a produit actuellement 52 kg/arbre. Elle se classe la troisième après Bradshaw bleu et la Reine-Claude. Par contre, les poiriers ont produit moins qu'en 1983 (Clapp's Favorite 5,9 minot en 1983 vs 4,6 en 84).

FERME EXPÉRIMENTALE NORMANDIN

Les céréales

Une analyse menée chez l'orge sur la résistance et la tolérance au virus de la jaunisse nanisante (VJNO) et au virus de la mosaïque strillée de l'orge (VSMO) montre la tolérance moyenne du cultivar Moreval au VMSO. L'étude montre aussi une forte hétérose chez l'hybride de deux parents résistants au VJNO, ce qui pose l'hypothèse de gènes différents de résistance chez ces deux cultivars.

Un essai de fertilisation azotée des blés de printemps, Glenlea et Opal, mené pendant quatre années montre la réponse favorable du cultivar Opal à une augmentation de la dose d'azote. La réponse du rendement à l'augmentation d'azote chez le cultivar Glenlea est trop inconsistante d'une année à l'autre pour permettre d'identifier le meilleur traitement. Le fractionnement de l'application de la fumure azotée est sans effet par rapport à une application unique en pré-semis.

La gourgane

Le comportement d'un des meilleurs cultivars de gourgane (*Vicia faba var. major*), Baie Saint-Paul, a été décrit et les résultats démontrent que ce cultivar a produit un rendement potentiel moyen de 14 417 kg/ha de gousses vertes fournissant un rendement moyen de 5 818 kg/ha de grain vert contenant un pourcentage moyen de 82,3 % d'humidité. Le grain vert à la récolte a occupé en moyenne 39,7 % du poids total de la gousse.

Les plantes fourragères

Une grosse fourragère a été construite pour le nettoyage des parcelles expérimentales en plantes fourragères après que les échantillons servant à déterminer les rendements et/ou d'autres caractères agronomiques ont été prélevés. Cette fourragère compacte, agréable d'opération, qui permet une plus grande efficacité de la main-d'oeuvre et une économie de temps, peut être utilisée pour la prise d'échantillons lorsque de grandes parcelles sont requises pour atteindre les objectifs expérimentaux.

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Station de recherches, Saint-Jean-sur-Richelieu, Québec

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T. Otis, BSc(Agr)	Agent d'information

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M. Trudelle,[3] BSc(AgrEng)	Spécialiste des sols

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C. Richer-Leclerc, BSc(Agr), MSc	Gestion des plantes ornementales

Départ

L.E. Parent, BSA, MSc, PhD	Physique des sols

GOUVERNEMENT DE LA PROVINCE DE QUÉBEC

M. Mailloux, BSA, MSc	Entomologie

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[1]Détaché de la Direction générale des affaires financières et administratives, Division des systèmes et services consultatifs.
[2]Détaché de la Direction générale des affaires financières et administratives, Division des bibliothèques.
[3]Présentement aux études pour l'obtention d'un doctorat (Ph.D.).

INTRODUCTION

La station de recherches de Saint-Jean-sur-Richelieu et sa ferme expérimentale de l'Assomption travaillent à résoudre les problèmes reliés à la production des plantes horticoles, du maïs, du tabac, des plantes ornementales et des fines herbes. Les programmes de recherche sont orientés vers la régie, la fertilité, l'amélioration et la protection de ces plantes. Tel que prévu, cette année, le personnel de la station de Saint-Jean-sur-Richelieu a aménagé dans un nouvel immeuble, le 5 septembre. Ce rapport offre un bref aperçu des résultats obtenus en 1983. Pour de plus amples renseignements, veuillez vous adresser à: Station de recherches, Direction générale de la recherche, Agriculture Canada, C.P. 457, Saint-Jean-sur-Richelieu, Québec, Canada, J3B 6Z8.

Claude B. Aubé
Directeur

LÉGUMES

Sensibilité de la carotte au charançon

Le charançon de la carotte, *Listronatus oregonensis* demeure le principal ravageur de la carotte au Québec. Jusqu'ici, seul l'emploi des insecticides permet aux producteurs de combattre cet insecte. Quinze cultivars de carottes ont été évalués en sol organique, pendant 2 ans à Sainte-Clotilde, pour leur sensibilité au charançon. Des différences très significatives ont été obtenues entre les cultivars, et la sensibilité s'est maintenue constante d'une année à l'autre. Les cultivars Joba, Nandor et Gold Pak 28 ont été les moins attaqués. Ces essais démontrent qu'aucun de ces cultivars n'offre un degré de résistance acceptable à cet insecte. Certains sont moins attaqués, subissant la moitié des pertes subies chez les plus sensibles. Il faut considérer ce point lors du choix d'un cultivar de carotte.

Ravageurs de l'oignon et de la pomme de terre

Essai en sol organique, à Sainte-Clotilde, sur pomme de terre (Kennebec) et oignon (Canada Maple), avec traitements préventifs effectués de façon à laisser libre cours à l'action de l'insecticide, de l'herbicide, du fongicide ou de leurs actions combinées. Pour ces deux légumes, la combinaison d'un insecticide et d'un herbicide représente le seul type de traitement qui donne des résultats différents du témoin. Chez l'oignon, le traitement à l'herbicide seul, en réduisant la présence des mauvaises herbes, permet un développement de l'oignon dont le rendement n'est pas significativement différent du traitement combiné insecticide–herbicide. En sol organique, les mauvaises herbes ou plantes adventices représentent le facteur limitatif de production de ces deux légumes. Les principales espèces sont l'amarante, le chénopode glauque, le pourpier et la moutarde des chiens. Seuls le chlorpropham (CIPC), l'allidochlor (Randox) et l'ioxynil (Toctril) sont présentement homologués pour l'oignon en sol organique.

Désordres physiologiques du chou entreposé

Des symptômes de la griselure du limbe (grey speck) et la bigarrure nervale (vein streaking), deux désordres physiologiques, ont été observés pendant 3 ans sur plusieurs cultivars de chou d'hiver entreposés. La bigarrure nervale affecte plus sévèrement les feuilles externes de la pomme de chou; toutefois, ces deux désordres sont bien distincts en nature parce que plusieurs cultivars résistants à la griselure du limbe sont sensibles à la bigarrure nervale. Les cultivars sensibles aux deux désordres ne présentent pas la même incidence de leurs symptômes. L'entreposage en atmosphère contrôlée (AC) élimine totalement la griselure du limbe, mais pas toujours la bigarrure nervale. Pour éviter ces désordres d'entreposage, utiliser un cultivar reconnu moins sensible et possédant un bon potentiel d'entreposage comme le cultivar Decema Extra.

Lutte contre le doryphore de la pomme de terre

Des essais en sol organique à Sainte-Clotilde avec le cultivar Kennebec ont permis d'évaluer, à l'aide de comptages des larves et adultes sur 80 plants choisis au hasard, l'action de produits insecticides et leur rémanence contre le doryphore de la pomme de terre (*Leptinolarsa decemlineata*). Le seuil d'intervention de 10 larves par plant a déterminé les traitements. Les produits Décis, Fastec, Fluvalinate, Alsystin + Monitor, SN72129, *B. thuringiensis* (forme 8-exotoxine) et Baythroid ont donné des rendements commerciaux significativement différents des lots témoins. L'efficacité des produits sous forme granulée semble déterminée par leur rémanence dans le sol et Temik 15G a pu maintenir la population d'insectes en deçà du seuil d'intervention jusqu'à la mi-août.

Nouveau cultivar de chou résistant à la hernie

Le cultivar de chou Acadie, nommé en 1984, est résistant aux races 1 et 6 du pathogène *Plasmodiophora brassicae* qui cause la hernie des crucifères, maladie considérée comme la plus importante dans les cultures de crucifères. Plusieurs races de l'organisme pathogène ont été identifiées à travers le monde. Acadie a été évalué pour sa résistance à la hernie au Canada (Québec, C.-B.), aux USA (Wisconsin) et en Nouvelle-Zélande (Lincoln) et les essais se sont révélés concluant pour ce qui est de la race 1 et 6 de *P. brassicae*. Le nouveau cultivar s'adapte bien, a une excellente apparence et est de très bonne qualité.

De plus, six lignées résistantes consistant en une lignée mâle stérile et une lignée mâle fertile pour chacune des espèces de choux, brocoli et chou-fleur ont également été cédées aux multiplicateurs. Les trois lignées mâles stériles sont tolérantes à la chlorose hypothermique.

La fusariose chez l'asperge

Un inventaire a été effectué en 1982–1983 sur des semences, griffes et plants d'asperge en production dans le but de vérifier si certains champignons, notamment *Fusarium oxysporum* f. sp. *asparagi* et *F. moniliforme* sont responsables du déclin des aspergeraies observe récemment au Québec. Ces deux espèces de *Fusarium* ont été retrouvées respectivement sur 93 % et 61 % de plants examinés dans les aspergeraies. Même si les tests de pathogénicité menés avec *F. oxysporum* et *F. moniliforme* ont été positifs, les symptômes du champ ne permettent pas de conclure que la fusariose soit à l'origine d'un quelconque dépérissement.

Nématodes entomophages contre le charançon de la carotte

Afin d'établir une lutte intégrée contre le charançon de la carotte *Listronatus oregonensis*, on a vérifié la sensibilité de cet insecte à l'infection de trois espèces de nématodes des parasites *Neoaplectana carpocapsae* (DD-136), *N. bibionis* (T335) et *Heterorhabditis heliothidis*. Le taux de mortalité des larves du charançon a été de 100 % pour les trois espèces de nématodes, 4 jours après le début de l'essai. Les pupes et adultes se sont montrés moins sensibles à ce type d'infection avec une mortalité de 79 % et 75 % respectivement après 6 jours. Bien que ces essais furent faits en plaques de Pétri, à température constante de 27 °C, il devient intéressant d'évaluer le nématode DD-136 incorporé au sol, en serre et en plein champ, afin de connaître le potentiel de ce parasite comme agent de lutte biologique contre le charançon de la carotte. Le DD-136 est l'espèce qui a tué le plus rapidement l'insecte-hôte en provoquant des taux de mortalité supérieurs aux deux autres espèces, 24 h après inoculation.

Le nématode des nodosités chez la carotte

Le nématode des nodosités, *Meloidogyne hapla*, occasionne d'importantes pertes de rendement dans les cultures maraîchères du Québec, notamment dans les cultures de carotte. Dans les champs fortement infestés, il peut y avoir perte totale, surtout là où la rotation des cultures n'est pas pratiquée. Le prix ascendant des fumigants et la menace de voir disparaître du marché des biocides de plus en plus contestés accentue la nécessité d'évaluer d'autres méthodes de lutte, notamment les façons culturales. Des études en sol organique sur l'incidence de la date et de la densité de semis de carotte sur les pertes causées par ce nématode ont démontré que la date de semis demeure un facteur déterminant dans les pertes causées par le nématode. Pour le semis le plus hâtif (1er mai), les carottes vendables s'élevaient à 73 % et pour le semis le plus tardif (16 juin), à 21 %. La densité de semis n'a pas influencé le pourcentage de carottes endommagées. Il y a eu 53 % de carottes vendables avec l'hybride Spartan Classic et 40 % pour la variété Gold Pak 28.

PETITS FRUITS

Pollinisation dans une fraisière

Les insectes, en plus de la gravité ou le vent, contribuent généralement le plus à la pollinisation des plants de fraisier. On a cherché à identifier parmi neuf cultivars ceux qui furent les plus visités par les insectes pollinisateurs, les meilleurs pouvant servir comme parents dans un programme d'amélioration génétique. La fréquence des visites de l'abeille domestique et autres pollinisateurs pendant la floraison des plants ont servi à déterminer les cultivars les plus attirants. Il y a eu trois fois plus de visites d'abeilles et deux fois plus de visites d'autres insectes pollinisateurs chez le cultivar Elvira que chez Catskill. Des essais antérieurs ont démontré que les cultivars varient dans le spectre de réflectivité des pétales, à savoir que pour l'abeille, les fleurs n'ont pas toutes la même dimension, forme et couleur.

Amélioration génétique du fraisier

La valeur économique de la production canadienne de fraises et son potentiel d'expansion

nécessitent l'obtention de cultivars améliorés, adaptés à la récolte mécanique et à la transformation industrielle. L'amélioration génétique du fraisier est axée sur un programme d'hybridation et de sélection de nouveaux cultivars et sur l'évaluation des meilleurs cultivars américains et européens déjà existants. Aucun à date ne présente une synthèse satisfaisante de caractères, surtout pour ce qui concerne la fermeté des fruits. Les buts du programme de Saint-Jean, outre la fermeté des fruits, sont une plus haute concentration de maturation pour fin de récolte surtout mécanique, la résistance à la stèle rouge, un rendement élevé, les caractères morphogénétiques et les facteurs importants de l'attraction des fleurs de fraisier sur les agents pollinisateurs. Des différences marquées ont été observées chez les génotypes et laissent espérer des chances de réussite du programme d'amélioration.

ARBRES FRUITIERS

Dépistage du charançon de la prune en vergers de pommiers

Afin de connaître davantage le comportement du charançon de la prune *Conotrachelus nenuphar* en champ, une méthode de marquage des adultes a été mise au point pour permettre sa détection à distance. Il s'agit d'incorporer du zinc radioactif (^{65}Zn) à de la peinture et d'appliquer celle-ci sur le dos de l'insecte. En utilisant différentes couleurs, on peut connaître et suivre l'évolution dans le champ de chaque spécimen marqué. La détection en champ s'effectue en parcourant le site expérimental avec un compteur à scintillations. La technique permet jusqu'à 62 % de recaptures d'insectes marqués et de cartographier leurs déplacements. Il est maintenant établi que la majorité des charançons passent l'hiver en dehors des vergers et cette information s'avère importante pour la mise en place de programmes de lutte plus efficace.

Deux nouveaux éradicants contre la tavelure de la pomme

Deux nouveaux fongicides systémiques non homologués DPX-H6573 (Dupont) et RH-3866 (Rohm & Haas), appliqués en post-infection, se sont avérés très efficaces comme éradicants de la tavelure de la pomme *Venturia inaequalis*. Ils offrent une protection d'éradication de 96 h et leur action systémique résiduelle agit à des doses beaucoup plus faibles que les autres produits mis à l'essai. Dans des périodes difficiles d'infection comme celles connues en 1984, ces fongicides sont efficaces mais n'altèrent pas le fini et la coloration des fruits.

Répartition d'un pesticide sur pommiers

La répartition spatiale des pesticides sur pommiers après arrosage devient importante, notamment pour la mise au point de plans d'échantillonnage. On a donc déterminé quantitativement à Frelighsburg, la répartition d'un produit en se servant d'un marqueur fluorescent, la fluorescéine (Anachemia Co.), chaque arbre évalué ayant reçu environ 4,5 L de bouillie, soit 1 g de fluorescéine. Des différences significatives démontrent que la fluorescéine n'a pas été répartie également dans un pommier. Ainsi, au niveau des points cardinaux, les côtés est et ouest d'un arbre peuvent recevoir le double des concentrations, ces derniers donnant dans l'allée de passage de l'arroseuse, sont donc directement dans le jet de l'appareil. Aussi, le bas et l'extérieur d'un pommier reçoivent près de deux fois plus de produit. Si l'on désire connaître la distribution d'un pesticide présent sur un arbre, on devra recourir à l'échantillonnage stratifié, mais si l'on veut détecter la présence de résidus, on aura avantage à se concentrer dans le bas de l'arbre, à l'extérieur et dans les quadrants donnant sur l'allée.

TABAC ET PLANTES ORNEMENTALES

Méthodes culturales chez le tabac à cigare

Pendant 3 ans, on a étudié les variations des caractères agronomiques et morphologiques de la composition chimique du tabac à cigare en relation avec la distance de plantation, le stade et la hauteur d'écimage. Le stade d'écimage a modifié significativement le rendement, le revenu brut, le pourcentage de filasse de tête et la composition chimique du tabac à cigare. Par contre, la hauteur d'écimage n'a pas influencé les données agronomiques, bien que la composition chimique ait été modifiée. La distance de plantation a eu cependant un effet très marqué sur tous les paramètres, sauf le contenu de la filasse. Les résultats ont indiqué qu'un espacement de 30 cm entre les plants et l'écimage normal au stade de 50 % de floraison donnent les meilleurs rendements et revenus. Sous ces conditions, on retrouve la plus forte teneur en alcaloïdes totaux et en nicotine, et les feuilles sont aussi plus larges et longues.

Enracinement de deux types de conifères

La durée de la photopériode au cours de l'enracinement des boutures modifie leur rhizogénèse. Les solutions hormonales préparées à base de tiges lyophilisées de saule pleureur (*Salix alba*) et de peuplier de lombardie (*Populus nigra*)

possèdent certaines propriétés favorables à l'enracinement des boutures. Des boutures terminales de *Juniperus sabina* et *Thuya occidentalis* ont donc été soumises à deux photopériodes (l'une de 16 h et l'autre entre 9 h et 9 h 30 de lumière par jour) et à 12 traitements hormonaux préparés à base d'extraits de saule et de peuplier, combinés ou non avec l'acide indolebutyrique (IBA). Un meilleur enracinement a été observé pour les boutures soumises à une photopériode de 16 h produite à l'aide de lampes au sodium à haute pression chez les deux types de conifères et ce, pour la plupart des traitements hormonaux évalués, notamment les combinés (extraits + IBA).

Réseau d'essais des plantes ligneuses ornementales

Un réseau d'essais des végétaux ligneux ornementaux a été établi en 1984 et permettra d'obtenir des renseignements sur le comportement et la rusticité des arbres et arbustes ornementaux dans diverses régions du Québec.

L'introduction de 30 espèces ornementales a débuté au printemps dans neuf sites d'évaluation et des données phénologiques ont été prises au cours de l'été, le taux de rusticité sera observé au printemps 1985. Les trois centres de multiplication du réseau ont produit les 50 espèces qui doivent être introduites au printemps 1983. Il y a des arbres feuillus (20), des conifères (10), des rampants (5), des Éricacées (5) et des arbustes (10). La liste des 50 végétaux pour 1986 est établie et leur multiplication commencée.

MAÏS GRAIN

Reproduction massive de la pyrale du maïs

Afin de reproduire massivement la Pyrale du maïs (*Ostrinia nubilalis*) en chambre de croissance pour l'obtention d'oeufs utilisés dans des programmes d'amélioration génétique du maïs, deux diètes synthétiques à base d'agar et de germe de blé ont été comparées. La diète dite «Mason» s'est avérée plus facile et rapide à préparer que la diète dite «Ankeny», bien que la fécondité des papillons (nombre de masses d'oeufs/femelle) ne soit pas significativement différente selon que les spécimens provenaient de l'une ou l'autre des diètes. Cependant, la diète «Mason» offre l'avantage aussi d'obtenir plus de chenilles qui se chrysalident dans le carton ondulé placé dans le haut des plats de plastique contenant la diète de l'ordre de 20 à 30 % de plus, et les plats sont relativement exempts de moisissures. Le coût de fabrication de deux diètes demeure à peu près le même.

Aussi, deux techniques pour la collection des papillons pendant les élevages furent utilisées, soit la technique avec aspirateur électrique, ainsi que la méthode qui consiste à déposer directement les rondelles de carton ondulé contenant les chrysalides dans les cages de pontes. Cette dernière méthode a permis de doubler la fécondité des papillons femelle d'une façon statistiquement significative. Avec une production annuelle de près de 300 000 pontes à Saint-Jean, il devient économiquement rentable d'utiliser cette technique.

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Ontario Region
Région de l'Ontario

J.J. Cartier

H. Baenziger

D.G. Proctor

Director General *Directeur général*	J.J. Cartier, BA, BSc, PhD
Program Specialist *Spécialiste en programmes*	H. Baenziger, Ing Agr, MSc, PhD
Chief, Administration *Chef de l'administration*	D.G. Proctor

PREFACE

The Ontario Region, with headquarters in Ottawa, includes nine research establishments, four research stations, two research centers, and three experimental farms. A staff of 870, of which about 175 are professionals, operates with a budget of about $35–40 million.

The Animal Research Centre in Ottawa conducts research on beef and dairy cattle, swine, poultry, and sheep; animal waste management; and food safety and nutrition. Up-to-date biotechnology methods are being emphasized in animal research today. They focus on genetic manipulation of rumen bacteria and on embryo manipulation. During 1984 the Animal Research Centre reached a milestone when the government approved construction of a new office–laboratory on the Greenbelt Farm. An official sod-turning ceremony was held in December.

At the Ottawa Research Station plant-breeding programs are conducted in cereals, forages, soybeans, and some ornamentals. Improved cultivars or hybrids have resulted, for example Leger barley and Maple Arrow soybean. In forage legumes the capability for nitrogen fixation in alfalfa and red clover is also being improved.

In ornamentals numerous flowering shrubs, particularly roses, have been introduced, with better adaptation to our harsh climate. A biotechnology center of excellence is being developed according to plan, and some practical results are emerging. The Kapuskasing Experimental Farm cooperates with the Ottawa Research Station and the Animal Research Centre on developing improved beef production systems based on adapted, locally produced feeds. The Thunder Bay Experimental Farm evaluates adaptation of forage, grain, and horticultural crops to the area. At the end of 1984 the Director of the Ottawa Research Station, Dr. Tibor Rajhathy, retired after a distinguished career with Agriculture Canada.

Research at the Vineland Research Station focuses on integrated pest management for orchard and vegetable crops, grapes, ornamentals, some forage crops, and mushroom production. These programs aim to reduce the use of chemical pesticides while maintaining crop productivity and produce quality. The station also maintains a virus-free nuclear stock repository of strawberries, raspberries, and tree fruits. The Smithfield Experimental Farm conducts plant-breeding research in apples and tomatoes and crop management work in orchard and vegetable crops. Pest monitoring in orchards is essential to the integrated pest management approach. In support of local industries Smithfield also features some produce-processing research.

The Delhi Research Station is the center for research on flue-cured tobacco in Canada, serving the industry in Ontario, Quebec, and the Maritimes. Growers are implementing the improved cultivars and production technologies being developed. The use of improved Delhi cultivars in Ontario has increased recently from about 50% to well over 90%.

The London Research Centre concentrates on research in integrated pest management and environmental quality. The management of insects, diseases, and weeds is studied for ways to reduce the reliance of the agri-food industry on chemical pesticides. Biological pest control methods are assessed, while the search continues for new, environmentally safer control strategies. The London Research Centre is slated to have its facilities upgraded in the next 2 or 3 yr. Agriculture Canada is purchasing a property near London on which a new building will be constructed to house the staff now located in the "annex". The site will also serve as a station for all field experimentation.

The Harrow Research Station serves the climatically most-favored area of Ontario. Southwestern Ontario produces a great variety of crops and consequently Harrow has the most diverse research program in the region. Research is being conducted on field crops, on several tree fruit and vegetable species, and on greenhouse crops. These programs aim to develop improved cultivars and superior production technologies. The development of efficient integrated pest management techniques is also a high priority. During 1984 the Harrow Research Station celebrated its 75th anniversary. At the time of the celebrations the Woodsley Substation was renamed The Hon. Eugene F. Whelan Experimental Farm.

Information on the various programs may be obtained by writing to the establishments concerned or to Ontario Region Headquarters, Research Branch, Agriculture Canada, Central Experimental Farm, Ottawa, Ont. K1A 0C6.

J.J. Cartier
Director General

PRÉFACE

La région de l'Ontario, dont l'administration centrale est à Ottawa, comprend neuf établissements, quatre stations et deux centres de recherches, ainsi que trois fermes expérimentales. L'effectif de 870 employés, dont environ 175 sont des professionnels, utilisent un budget de l'ordre de 35 à 40 millions de dollars.

Au centre de recherches zootechniques d'Ottawa, on effectue des études sur les bovins laitiers et de boucherie, sur le porc, la volaille et les moutons; sur l'utilisation des déchets animaux; ainsi que sur la valeur nutritive et la salubrité des aliments. Aujourd'hui, on met l'accent sur l'utilisation des méthodes biotechnologiques les plus récentes dans la recherche. Ces méthodes sont axées sur la manipulation génétique des bactéries du rumen et la transplantation d'embryons. Au cours de 1984, le Centre de recherches zootechniques a franchi une étape importante lorsque le gouvernement a approuvé la construction d'un nouveau complexe bureaux-laboratoires à la Ferme de la Ceinture verte. La levée de la première pelletée de terre a eu lieu en décembre.

À la station de recherches d'Ottawa, les chercheurs exécutent des programmes de sélection des plantes visant les céréales, les cultures fourragères, le soja et quelques plantes ornementales. Parmi les cultivars ou hybrides améliorés issus de ces activités, figurent l'orge Léger et le soja Maple Arrow. Chez les légumineuses fourragères, notamment la luzerne et le trèfle rouge, on améliore progressivement la capacité de fixation de l'azote.

Pour ce qui concerne les plantes ornementales, on a réussi à implanter de nombreux arbustes à fleurs, en particulier des rosiers, qui sont mieux adaptés à la rigueur de notre climat. La mise sur pied d'un centre d'excellence biotechnologique progresse selon les prévisions, et on a déjà obtenu divers résultats pratiques de ce programme. La Ferme expérimentale de Kapuskasing coopère avec la station de recherches d'Ottawa et le Centre de recherches zootechniques à la mise au point de systèmes améliorés de production de bovins de boucherie utilisant des aliments du bétail adaptés aux conditions locales et produits sur place. La Ferme expérimentale de Thunder Bay évalue l'adaptation locale de certaines plantes fourragères, céréalières et horticoles. À la fin de 1984, le directeur de la station de recherches d'Ottawa, Tibor Rajhathy, a pris sa retraite après une brillante carrière à Agriculture Canada.

Les recherches à la station de Vineland portent principalement sur la lutte intégrée dans les cultures fruitières et légumières, les cultures vinicoles, les cultures ornementales, quelques cultures fourragères et les champignonnières. Ces programmes ont pour objet de réduire l'emploi des pesticides chimiques tout en maintenant la productivité des cultures et la qualité des produits. La station exploite en outre une banque de matériel-souche de fraisiers, de framboisiers et d'arbres fruitiers exempts de virus. À la ferme expérimentale de Smithfield, les chercheurs se penchent sur l'amélioration des pommiers et des plants de tomates et effectuent des travaux sur la conduite des cultures fruitières et légumières. Le contrôle des populations de ravageurs dans les vergers est l'un des aspects essentiels de la lutte intégrée. Pour appuyer les industries locales, les chercheurs de Smithfield font également des études sur la transformation des produits.

La station de Delhi est le centre national de recherches sur le tabac jaune. Elle prête son concours au secteur du tabac en Ontario, au Québec et dans les Maritimes. Les producteurs de tabac utilisent les cultivars améliorés et les techniques de production qui y sont mises au point. En Ontario, l'utilisation des cultivars améliorés de Delhi est passée récemment d'environ 50% à au-delà de 90%.

Le Centre de recherches de London concentre ses travaux sur la lutte intégrée contre les ravageurs des cultures et sur la qualité de l'environnement. Les études sur l'enraiement des insectes, des maladies et des mauvaises herbes ont pour objet de réduire la dépendance du secteur agro-alimentaire à l'égard des pesticides chimiques. On évalue les méthodes de lutte biologique et l'on continue à chercher de nouvelles stratégies de lutte moins nuisibles à l'environnement. On prévoit rénover les installations du Centre de recherches de London d'ici à 2 ou 3 ans. Agriculture Canada est en voie d'acheter un terrain près de London, où il fera construire un nouvel édifice pour héberger le personnel qui travaille actuellement dans l'"annexe". Le site servira aussi de station pour la conduite de toutes les expériences au champ.

La station de recherches de Harrow dessert la région de l'Ontario où les températures sont les plus clémentes. Le sud-ouest de l'Ontario produit une grande diversité de cultures, ce qui fait que la station de Harrow affiche le programme de recherches le plus diversifié de la région. Des recherches sont actuellement en cours sur les grandes cultures, sur plusieurs espèces arbustives, fruitières et légumières et sur les cultures de serre.

Ces programmes visent à mettre au point des cultivars améliorés et des techniques de production supérieures. L'élaboration de techniques efficaces de lutte intégrée occupe aussi un rang

privilégié. La station a fêté son 75e anniversaire en 1984 et, à cette occasion, la station satellite de Woodsley a été rebaptisée la ferme expérimentale Honorable Eugène F. Whelan.

Pour de plus amples renseignements sur les divers programmes, veuillez écrire aux établissements concernés ou vous adresser à l'administration centrale de la région de l'Ontario, Direction générale de la recherche, Agriculture Canada, Ferme expérimentale centrale, Ottawa (Ont.), K1A 0C6.

J.J. Cartier
Directeur général

Animal Research Centre, Ottawa, Ontario

PROFESSIONAL STAFF

Administration

R.S. Gowe, BSA, MS, PhD, FPSA	Director
J.I. Elliot,[1] BSA, MSc, PhD	Deputy Director
D.A. Leger, BSc	Assistant to the Director
D.A. Schmid,[2] BA	Chief, Administration and resources
G.R. Ford[3]	Administrative Officer, Personnel

Scientific Support

K.G. Hilson,[4] BSc, MSc	Project Manager; Computer services
D.L. Brewin[4]	Programmer–Analyst
D. Campbell[4]	Programmer–Analyst
B.J. McKelvey	Programmer–Analyst
H.M. Mucha[4]	Programmer–Analyst
T.D. Osterhout	Programmer
K.E. Hartin, DVM	Veterinarian
J.P. Miska,[5] BA, BLS	Library services

Animal Waste Utilization Program

N.K. Patni, BChE, MSc, PhD	Program Chairman; Livestock waste utilization, farm pollution abatement

Biotechnology

J.S. Gavora, Ing, CSc	Program Chairman; Disease resistance genetics
D.E. Bernon,[6] BSc(Agr), MSc, PhD	Cellular, molecular, and quantitative genetics
A.J. Hackett, DVM, MSc, PhD	Embryo transfer, female reproductive physiology
G.J. Marcus, BA, PhD	Maternal–embryonic physiological interactions
J. Nagai,[7] BSc, DAgr	Embryo manipulation—quantitative genetics
M.P. Sabour,[8] BSc, PhD	Molecular and cellular genetics
R.M. Teather, BSc, PhD	Genetic manipulation of rumen bacteria

Dairy Cattle Breeding and Production Program

A.J. Lee, BSc(Agr), PhD	Program Chairman; Dairy cattle breeding and production—applied quantitative genetics
T.R. Batra, BVSc, MVSc, PhD	Dairy cattle breeding—applied quantitative genetics
C.Y. Lin, BS, MS, PhD	Dairy cattle breeding—applied quantitative genetics
A.J. McAllister, BS, MS, PhD	Dairy cattle breeding and production—applied quantitative genetics

Dairy and Beef Cattle Nutrition Program

M. Ivan, Ing, MSc, PhD	Program Chairman; Nutrition and metabolism of trace minerals
A.S. Atwal, BSc, MSc, PhD	Forage evaluation and nutrition
J.D. Erfle, BSA, MSc, PhD	Rumen metabolism and nutrition
M. Hidiroglou, DVM, Dip Nutr	Vitamin D nutrition
K.J. Jenkins, BSA, MSc, PhD	Calf nutrition
J.R. Lessard,[9] BA, BSA, MS, PhD	Forage conservation and nutrition
S. Mahadevan, BSc, MSc, PhD	Rumen metabolism and nutrition
F.D. Sauer, DVM, MS, PhD	Rumen metabolism and nutrition
D.M. Veira, BSc, MSc, PhD	Ruminant nutrition

Swine Production Program

D.W. Friend, BSc, MSc, PhD	Program Chairman; Sow and piglet nutrition
J.I. Elliot,[1] BSA, MSc, PhD	Sow nutrition, artificial rearing
A. Fortin,[10] BSc(Agr), PhD	Carcass evaluation—swine, poultry, sheep, cattle
D.G. Fraser, BA, PhD	Animal behavior—swine, sheep, cattle

Poultry Breeding Program

A.A. Grunder, BSA, MSc, PhD	Program Chairman; Eggshell quality genetics, broiler breeding, goose breeding, and management
J.R. Chambers, BSc, MSc, PhD	Broiler breeding and management
R.W. Fairfull, BSc, MSc, PhD	Egg stock breeding and management
R.S. Gowe, BSA, MS, PhD	Egg stock breeding and management
C.P.W. Tsang, BSc, MSc, PhD	Physiology—eggshell quality and egg production

Poultry Nutrition Program

E.R. Sibbald, BSc(Agr), MSc, PhD, DSc	Program Chairman; Avian energetics and feedingstuff evaluation
N.A.G. Cave,[11] BSc, MSc, PhD	Amino acids and proteins, broiler breeder nutrition and management
R.M.G. Hamilton, BSc(Agr), MSc, PhD	Nutrition and physiology, eggshell quality, mycotoxins

Sheep Production Program

L. Ainsworth, BSc, MSc, PhD	Program Chairman; Female reproductive physiology
P.S. Fiser, BSc, MSc, PhD	Male reproductive physiology
D.P. Heaney, BS, MS, PhD	Nutrition and intensive management
G.A. Langford, BSc, MSc, PhD	Male reproductive physiology
J.N.B. Shrestha, BVScAH, MS, PhD	Breeding and intensive production—applied quantitative genetics

Animal Feed Safety and Nutrition Program

H.L. Trenholm, BSc, PhD	Program Chairman; Mycotoxins, toxicology
M.H. Akhtar, BSc, MSc, PhD	Pesticide metabolism and residues
L.M. Coté,[12] BSc, MSc	Biochemical toxicology, mycotoxins

E.R. Farnworth,[13] BSc, MSc, PhD	Lipid nutrition and metabolism
J.K.G. Kramer, BSc, MSc, PhD	Lipid chemistry and biochemistry
D.B. Prelusky, BSc(Pharm), PhD	Mycotoxin metabolism, toxicology

Departures

J.R. Harrison, BSc Transferred to Department of National Defense, 27 November 1984	Administrative Officer, Finance
N.K. Sarkar, BSc, MSc, DSc Retired, 2 February 1984	Protein biochemistry
G.I. Smith, BMath On leave as of 1 January 1984 for an indefinite period	Programmer–Analyst

VISITING SCIENTISTS

W. Guenter, PhD Department of Animal Science, University of Manitoba, Winnipeg, Manitoba	Eggshell quality
Y. Lu, MD Laboratory Animal Centre, Beijing, China	Laboratory animal breeding
I. Okada, DAgr Faculty of Applied and Biological Sciences, Hiroshima University, Fukuyama, Japan	Avian immunogenetics
D. Perotto, MSc Parana State Agricultural Research Institute, Londrina, Parana, Brazil	Dairy cattle breeding and management
F. Strudsholm, BSc National Institute of Animal Science Research (Cattle and Sheep), Orum Sonderlyng, Denmark; Government of Denmark training fellowship	Calf nutrition
C. Lacôte, BSc National Institute of Agronomy, Paris–Grignon, France; Government of France training fellowship	Lipid research
T. Michelin, MSc National Centre for Swine and Poultry Research, Concordia, Brazil; United Nations Development Programme–Food and Agriculture Organization training fellowship	Poultry breeding management
B.C. Foster, BSc, PhD Natural Sciences and Engineering Research Council postdoctorate fellow, 1984–1985	Toxicology of mycotoxin-contaminated grains
R. Gopinath, BSc, MSc, PhD 1984–1985	Urea metabolism in ruminants

C.A. Kelleher, BSc, PhD 1983–1985	Mineral metabolism
T. Tennessen, BA, BSc, MSc, PhD 1983–1984	Swine production
K.H. Ponzilius, BSc, MSc, PhD 1984–1985	Embryo splitting and manipulation

Graduate student

J.C. Segura, CIng	Poultry genetics

[1]Acting Deputy Director, 1 January 1984–31 March 1984. Appointed 1 April 1984.
[2]Appointed 13 February 1984.
[3]Acting Chief, Administration and Resources, 1 January 1984–10 February 1984; Acting Administrative Officer, Finance, from 15 November 1984.
[4]Seconded from Systems and Consulting Directorate, Finance and Administrative Branch.
[5]Seconded from Libraries Division, Finance and Administration Branch.
[6]On transfer of work at the Cellular Genetics Laboratory, National Institute for Research in Agriculture (INRA), Toulouse, France. 29 November 1984–1 December 1985.
[7]On transfer of work at Tohoku University, Sendai City, Japan. 11 April 1983–13 February 1984.
[8]Appointed 3 December 1984.
[9]Seconded to Research Branch, Program Coordination Directorate, 1 November 1981–31 December 1984.
[10]On transfer of work at Meat Research Institute, Agriculture Research Council, Langford, Bristol, England, 17 October 1983–1 November 1984.
[11]On transfer of work at the Small Animal Breeding Institute, Belgium Ministry of Agriculture, Merelbeke, Belgium. 1 August 1984–1 August 1985.
[12]On education leave at the University of Illinois, Urbana, Ill., as of 21 June 1982 for an indefinite period.
[13]On transfer of work at the Pig Husbandry Department, National Institute for Research in Agriculture (INRA), Saint Gilles, France. 15 August 1984–15 August 1985.

INTRODUCTION

The Animal Research Centre (ARC) is the main Canadian location for breeding and genetics research with dairy cattle, sheep, and poultry; it also has major research programs in the nutrition of dairy and beef cattle, poultry, swine, and sheep. In addition, research is under way in animal waste utilization and management, dietary utilization of fats and oils, reproductive physiology of all species, trace mineral requirements of sheep and cattle, animal behavior, carcass evaluation of all species, ruminant digestive physiology, pesticide metabolism, and effects and metabolism of other contaminants in animal feeds. The nine research program teams are multidisciplinary and are composed of scientists with a broad range of scientific knowledge. Both applied and basic studies, directly related to the solution of the problem, are carried out within these teams. The major research goal of the center is the resolution of the numerous problems associated with improving the productive efficiency of intensively housed and managed livestock and poultry.

In 1984, the program structure was thoroughly reviewed and modifications were made. Several program chairpersons were rotated. The dairy and beef cattle nutrition groups were combined with the scientists working in the areas of trace minerals and vitamin utilization to form a comprehensive dairy and beef cattle nutrition program. This amalgamated program will better represent the total ARC contribution in the major program area of ruminant nutrition.

The use of genetic engineering techniques and research on molecular genetics and embryo manipulation hold great potential as valuable tools for improvement of Canadian livestock and poultry production. Research in a number of these areas has been under way at ARC for several years in the separate areas of animal and poultry breeding and genetics, reproductive physiology, and rumen microbiology. To recognize the center's increasing research in biotechnology, a new biotechnology program was created consisting of scientific staff previously assigned to other program teams. This broadly based, multidisciplinary team was further strengthened by the addition of a new scientist with specialized knowledge of cellular and molecular genetics.

This new biotechnology program has work in progress in the genetic engineering of rumen bacteria and embryo manipulation, and on the development of early prediction of milk production potential in dairy cattle using hormones and tissue culture. Other projects will focus on tissue culture, cell manipulation, and DNA manipulation for application to research on genetic resistance to disease.

This annual report highlights research progress in 1984. Some advances that are particularly noteworthy: it was found that selenium pellets are effective intraruminally to control nutritional muscular dystrophy; ammonia was shown to reduce deterioration in large round bales of alfalfa hay; a two-tier pen improves the environment for intensively housed swine; a number of grass silages result in good performance for beef and a fish-meal supplement gives a large improvement in silage utilization; vomitoxin residues in contaminated feedstuffs are not transmitted to edible animal products such as eggs or milk; further progress was made in understanding the role of heterosis in poultry egg production; the heritability of various traits was established in the national cattle breeding experiment; a stable enzyme preparation was developed to assess feed proteins for ruminants; the puncture test is a practical, direct method for measuring the material strength of eggshells; the use of vaginal smears increases the accuracy of prediction of pregnancy in sheep; the metabolism and breakdown of the pesticide deltamethrin were established in poultry; and extensive data have been analyzed to evaluate the selection and crossbreeding program for intensive sheep production.

The transfer of research results from the laboratory to the farmer–user remains a high priority. Efforts in this regard were exemplified by the quantity of high-quality research data that are published in over 80 scientific articles and in more than 75 technical and popular-press articles. An increasing number of the scientific staff are invited to international symposia and conferences. Representative of this was the visit by Ian Sibbald to Southeast Asia to teach the true metabolizable energy (TME) assay for feedstuff evaluation at a number of research and commercial centers.

Among over 200 visitors to the Central Experimental Farm, ARC was especially honored with a tour by the President of Portugal.

The center continued extensive involvement in international cooperative research and development programs in Venezuela, Brazil, the Philippines, and Cuba in the areas of dairy cattle and poultry breeding and dairy cattle production research. Under these and other programs, an increasing number of scientists from developing and developed countries are chosing ARC as a location for professional development and training.

Members of the research staff continue to be recognized for their scientific excellence. In July 1984, Michel Hidiroglou was presented with the American Feed Manufacturers Award by the American Veterinary Medical Association for his mineral and vitamin research. Later, he joined Ken Jenkins, as both received the Canada Packers Medal for excellence in animal nutrition. The research of John Kramer and Frank Sauer continues to receive acclaim. These ARC scientists were presented with the CSP Foods Canola Research Award by the Canola Council of Canada.

The election of Robb Gowe as a fellow of the Poultry Science Association is an honor that has been given to few Canadians. Further recognition of his accomplishments as a Canadian and an internationally recognized research scientist and manager occurred at the annual meeting of the Canadian Society of Animal Science, where he received the Certificate of Merit.

For the third time in 6 years, an ARC researcher received the prestigious Merit Award of the Government of Canada. Jan Gavora was honored for his outstanding research on breeding for resistance to disease in poultry. Recognition was also given to several members of the support staff for their contributions to the efficient operations of the center.

A major step in the development program for the Central Experimental Farm was the official sod-turning and start of construction of the office–laboratory building. This structure will provide modern laboratory and office facilities and will house all the scientific, technical, administrative, and executive staff.

Detailed information on the research accomplishments, methodology, and results can be obtained from the publications listed at the end of this report. Reprints of these publications and copies of this report are available on request from the Animal Research Centre, Headquarters Building, Research Branch, Agriculture Canada, Ottawa, Ontario K1A 0C6.

R.S. Gowe
Director

ANIMAL WASTE UTILIZATION

Changes in composition of animal wastes during storage

Changes in the total solids (TS), carbon, and mineral content of dairy cattle manure slurry during undisturbed storage in farm-size, covered concrete tanks, 12.3 × 7.2 × 3.0 m deep were determined. The initial slurry TS concentration was 9–10% by weight. At the end of 146 and 285 days of storage, TS concentration decreased significantly, by 13 and 25%, respectively. This decrease was mainly due to a loss of carbon, mostly from the top 1-m depth. Lack of a substantial increase in TS concentration near the bottom of the tanks indicated that settling of solids was relatively small. Dry-basis concentrations of ash, phosphorus, potassium, calcium, and magnesium at the end of the storage period were significantly greater than the initial concentrations because of the decrease in TS content. A wide spatial and temporal variation in TS and in dry-basis ash and mineral concentrations was noted to a depth of about 1 m. These results showed the need for caution when using dry-basis concentrations to compare mineral content of manure slurries.

Effect of alternative manure-cropped systems on soil, crop, and water quality

The study to determine the long-term effects of manure application by disking, injection, side-dressing, and plowdown on soil, crop, and water quality continued in cooperation with the Land Resource Research Institute. Initial results indicate little difference in the quality of shallow groundwater resulting from the various manure application techniques.

Production of Canadian duckweed from liquid manure

The feasibility of producing Canadian duckweed, Lemnaceae, as a livestock feed supplement using lagoon-stored swine and dairy cattle manure as a substrate was investigated in a contract research project. Studies on greenhouses and pilot-scale plastic-lined ponds indicated that effective growth of duckweed required about 20-fold dilution of lagoon slurry, that is, slurry with a dry-matter concentration of 0.1–0.2% by weight. Nutrient analysis indicated that duckweed would provide a good supplementary source of protein and major minerals. Limited microbiological analysis indicated that in general, the presence of disease-causing organisms

in duckweed is not a cause for concern. However, because of the high dilution of manure that is required for reasonable growth rates, it was concluded that production of duckweed as a feed supplement using liquid manure was not practical under farm conditions in eastern Ontario.

DAIRY CATTLE BREEDING PRODUCTION

National cooperative dairy cattle breeding project (NCDCBP)

Preliminary comparisons of the purelines and crosslines for lactation yields over multiple lactations have commenced. All first-generation crosslines (HA, AH) have completed two lactations and almost all second-generation crosslines (C) have completed one lactation. Later lactation data are being accumulated for these groups and for contemporary pureline cows. Preliminary analyses of milk, butterfat, and protein yield have been completed.

In first lactation, the Holstein H line is superior to all other groups. The F_1 groups (HA, AH) show some hybrid vigor for milk yield whereas that for the second-generation C line is below the average of the two F_1 groups. There is some evidence to support the theory that hybrid vigor is reduced in subsequent generations of crossbreeding. Different patterns are seen in the second-lactation results where the H line retains a small advantage but it is reduced significantly over either the first- or second-generation crossbred. Hybrid vigor for second-lactation milk yield is maintained. The greatest increase in milk yield from first to second lactation is demonstrated by the second-generation crossbreds.

Another pattern is seen in third-lactation milk yields. Although the difference between the Ayrshire-based A and the Holstein-based H purelines is nearly the same as for the first two lactations, there is no hybrid vigor shown for the two F_1 groups. For the limited number of completed third lactations, the second-generation crossbreds are equivalent in milk yield to the H line (6341 versus 6099 kg, respectively). The inconsistent pattern of performance of the different groups from lactation to lactation indicates that no conclusions on lifetime milk yield potential can be made until complete lifetime yields of at least five lactations are available. The results also suggest genetic differences in rate of maturity for performance.

In the first lactation, the HA group has the highest butterfat yield whereas in the second lactation it is only equivalent to the H line yield and in the third lactation it is somewhat lower. The higher yields of the third lactation of the second-generation C line compared with the H line (236 versus 230 kg, respectively) indicates some advantage in butterfat percentage because milk yield for the two groups is nearly equivalent.

Effects of breeding age

An experiment was superimposed on the NCDCBP to study effects of age at first breeding on subsequent growth, production, and reproduction. A total of 253 heifers were bred at first heat after 350 days of age and 248 contemporary heifers were bred at first heat after 462 days of age. Average age at first calving was 23 and 26 mo for the 350-day and the 462-day groups, respectively. The 462-day group tended to have higher first-service conception rate than the 350-day group (47 versus 38%, respectively). The 462-day group lost an average of 42 kg from calving to 56 days postpartum compared with 23 kg for the 350-day group. Differences between the H, A, and C lines were not significant for reproduction traits except for gestation length and age at first heat. Station effects were significant for most reproduction traits.

Growth, reproduction, and lactation

Heritability estimates, and phenotypic and genetic correlations among first-lactation yields and prepartum and postpartum weight changes were calculated with a multitrait restricted maximum likelihood procedure using canonical transformation of the variables. Holstein heifers in the NCDCBP calve at an average age of 22.2 mo compared with about 28 mo in the dairy industry. Heritability estimates for first-lactation milk, protein, and fat yields were 0.26 ± 0.09, 0.31 ± 0.10, and 0.41 ± 0.11, respectively. Heritability estimates for prepartum and postpartum weights and weight changes are generally high, ranging from 0.33 ± 0.10 to 0.43 ± 0.11. This suggests that weight changes during first lactation can be altered through selection. The genetic and phenotypic correlations between milk yield and prepartum weights at 350, 462, and 574 days of age ranged from 0.20 to 0.49 and indicated that heavier heifers prior to calving tend to have higher first-lactation milk yield. Genetic and phenotypic correlations between first-lactation yields and postpartum weight changes were all negative, suggesting that heifers with higher first-lactation yields had greater postpartum weight loss.

Heritability estimates, and phenotypic and genetic correlations among reproduction traits, gestation length, body weight at calving, and milk yield were estimated from the data of H line

and A line heifers and cows. Heritability estimates for reproduction traits of the heifers (ages at first observed heat, first breeding, last breeding, days from first to last breeding, number of services per conception, first service conception rate, ease of calving, and placental condition) and cows (days to first breeding, days to last breeding, days from first to last breeding, number of services per conception, first service conception rate, ease of calving and placental condition) were generally low, ranging from 0 to 26%. Estimates for gestation length, body weight at calving, and milk yield were moderate, ranging from 16 to 43%. Phenotypic correlations between heifer reproduction traits and milk yield during first lactation were generally small at –0.10 to 0.06. Phenotypic correlations between cow reproduction traits and milk yield were slightly positive at 0.03 to 0.19. Phenotypic correlations between heifer and cow reproduction traits were small ranging from –0.16 to 0.14. These results suggest that there is some antagonism between reproduction traits and milk yield of the cows, although the genetic basis for this was not evident.

Mastitis

The relationship between somatic cell count and daily milk yield was studied using 2181 composite milk samples from 665 cows of the Ottawa herd of NCDCBP. The average somatic cell count for cows at first lactation and at all later lactations was 305×10^3 and 522×10^3 cell/mL, respectively. The decrease in daily milk yield was 0.4 and 0.7 kg for cows at first lactation and at all later lactations, respectively, when the somatic cell count increased from 200×10^3 to 400×10^3 cell/mL.

Breeding studies using record of performance (ROP) data

Canada is divided into 21 geographic zones on the ROP program, with each averaging 230–250 dairy herds. The importance of zone on the accuracy of extension factors that are used to estimate complete lactation performance from part records was evaluated. Zones did not have significant effects on deviations for milk or fat in cows either at first or later lactations. The results suggest that different extension factors are not required for the various geographic areas.

Heat detection in large dairy cattle herds

Freemartins treated with either estradiol or testosterone were used to detect heat. For 1027 heats only 23% were detected by the freemartins. Of these, 20% of 509 heats were detected by estradiol-treated freemartins and 25% of 518 heats by testosterone treatment. For comparison of treated and untreated females, 37% of the heats were detected by intact females, whereas 49% were detected by testosterone-treated females and 35% by estradiol-treated females. Herders observed 92% of all heats. Freemartins may be useful to help in heat detection, but they should be aggressive and free of leg problems. Testosterone may be the hormone of choice because estradiol can cause udder development.

DAIRY AND BEEF CATTLE NUTRITION

Beef production in the Great Claybelt of northern Ontario

At the Kapuskasing Experimental Farm in northern Ontario, Charolais-sired bull calves were used to compare direct-cut, formic-acid-treated grass silage made from either timothy, bromegrass, or an old mixed-grass sward composed mostly of red fescue and Canada bluegrass. The silages were offered ad libitum as the sole feed for 112 days following weaning at 6–7 mo of age. The three silages were made from the primary growth of the grasses at a comparable stage of maturity (boot) and were ensiled in horizontal silos. Feed intake of dry matter (DM) at 6.24 kg/day, gain at 0.73 kg/day and feed efficiency of DM at 8.78 kg/kg gain were the same for all silages and indicated that agronomic rather than nutritional factors should be the principal criterion for selecting grass species for the Great Claybelt area.

Further studies have examined the effect of supplementing direct-cut, formic-acid-treated grass silage (AGS) with a high rumen bypass protein such as fish meal. The AGS had a high protein content of 19.8%, but high organic acid and low soluble sugar content gave poor fermentation characteristics. Following weaning at 6–7 mo of age, 36 beef steers were fed the AGS ad libitum for 98 days either alone or supplemented with fish meal or barley at 0.5 kg/day. Both supplements increased total DM intake by an amount equivalent to the quantity offered but had no effect on silage intake. The fish-meal-supplemented steers gained 0.9 kg/day, which was substantially faster than gains for the barley or unsupplemented groups (0.53 and 0.54 kg/day, respectively). Fish-meal supplementation resulted in a large improvement in silage utilization.

Vitamin D

Levels of vitamin D_3 were determined for cows housed indoors and exposed to ultraviolet irradia-

tion (UVR) during the winter. It was found that exposure to UVR was associated with marked rises in plasma vitamin D_3. The response of plasma vitamin D_3 to UVR exposure in sheep that were raised in total confinement was also investigated, and it was observed that exposure to sun lamps produced a significant increase in plasma vitamin D_3 concentrations.

Prevention of muscular dystrophy in cattle

Intraruminal selenium pellets (ISP), developed in Australia, were evaluated as a means of controlling nutritional muscular dystrophy (NMD) in northern Ontario, where numerous calf losses occur from this disorder. Pregnant cows were winter fed grass silage from second-cut material, and in the spring the cows and calves were put on pasture. Eighty crossbred cows in the last trimester of pregnancy were given the ISP, and an equal number were used as controls. The efficacy of ISP was measured over a 3-yr period by determining the selenium (Se) status of the cows and calves as well as by the incidence of NMD. Plasma Se as well as glutathione perioxidase levels in whole blood in ISP cows were significantly higher than in controls. Ten mo after ISP administration, Se levels in tissues were considerably higher than in untreated cows, but were within normal ranges. Before the cows were turned out to pasture, milk Se levels of ISP cows were higher than in controls. This technique of dosing with Se was also highly effective in raising the Se status of the progeny. There was no clinical or postmortem evidence of NMD disorders in calves born from ISP cows. Fifteen control calves showed clinical symptoms of NMD in the first 2 yr.

Molybdenum (Mo) toxicity and copper (Cu) deficiency

In ruminants fed diets high in Mo, toxicity from Mo and physiological Cu deficiency are serious production problems. Physiological Cu deficiency arises from a complex interaction between Cu, Mo, and sulfur (S); the last converts part of the dietary Cu into insoluble, biologically unavailable complexes in the gastrointestinal tract and possibly in blood and tissues. In an experiment, four groups of six wethers were fed corn-silage-based diets with either low Mo (0.4 ppm), high Mo (8.4 ppm), low Mo and $CuSO_4$, or high Mo and $CuSO_4$.

Average daily gains and feed-to-gain ratios were depressed for the high-Mo diet as compared with the low-Mo diet, suggesting Mo toxicity in sheep fed the high-Mo diet. This toxicity was alleviated partly by the $CuSO_4$ supplement. The supplement did not elevate the concentration of Cu in the liver in spite of the fact that Cu concentrations in the $CuSO_4$-supplemented diets were twice those in the unsupplemented diets. These tissue concentrations were accompanied by Cu solubilities in the rumen that decreased almost proportionally to the increased dietary Cu in the $CuSO_4$-supplemented sheep. These results, together with a dramatic decrease in the ruminal solubility of Mo, suggest an interaction between Cu, Mo, and S in the rumen, which produces insoluble complexes. It is apparent that although $CuSO_4$ could be used as a supplement to control Mo toxicity, it probably would be less effective as a supplement in Cu-deficient diets.

Forage evaluation

Studies examined the effects of moisture content (MC) and the application of anhydrous ammonia (AA) on heating, chemical composition, and palatability of high-moisture alfalfa hay stored covered with plastic sheets in hard-core large round bales (LRB). Control LRB (1.7 × 1.7 m diameter) were heated to 66 and 82°C when initial MC was 26 and 33%, respectively. Slow application over 48 h of about 0.9% AA to a stock of LRB reduced the maximum temperatures to 53 and 47°C for hay baled at 29 and 39% MC, respectively. Excessive heating resulted in oxidative losses of 4.3 and 8.3% dry matter (DM) in LRB stored at 26 and 33% MC, respectively. For AA-treated LRB, oxidative losses were undetectable.

Almost all of the AA was retained in the LRB, which were then used for winter feeding. Crude protein content increased from 22.8 and 24% DM for control LRB baled at 26 and 33% MC, respectively, to 28.6% for AA-treated LRB. For AA-treated LRB, acid detergent lignin content measured during the winter feeding was similar to that at the time of storage (5.6% DM), whereas for control LRB baled at 26 and 33% MC, it increased to 6.6 and 17.3%, respectively.

It was also noted that LRB stored in a stack and preserved with AA must be used in winter in order to prevent mold growth and heating after removal of the plastic cover. The solubilization of AA is an exothermic reaction, and so AA should be applied slowly and not exceed 1%. An application of 3% AA to 25% MC LRB resulted in a temperature of 86°C at some spots and caused protein heat damage.

Calf nutrition

In a study on the influence of triglycerides and free fatty acids in milk replacers on lipids in blood plasma and adipose tissue, calves were fed milk replacers containing either tallow, corn oil, coconut oil, or the free fatty acids (FFA) derived

from these fats. It was found that all calves had similar relative amounts of each plasma lipid class. Cholesteryl esters and phosphatidylcholine were the main lipid classes, accounting for 50–57%, and 25–33%, respectively, of the total lipids. Smaller fractions were sphingomyelin (3–5%), cholesterol (5–8%), and triglycerides and FFA (2–5%). There were small but significant increases in both cholesterol and sphingomyelin when FFA were fed instead of the fat from which the FFA were derived. The cholesteryl esters contained high levels of linoleic acid (56–69%) even when dietary concentrations of linoleic acid were only 3–4% of the fat (e.g., tallow and coconut groups). Feeding corn oil containing high levels of linoleic acid raised this fatty acid in cholesteryl esters to between 84 and 87%. Concentration of saturated fatty acids in plasma cholesteryl esters was low both for the corn and coconut oil groups, even though their dietary concentrations were markedly different, at 17 and 90%, respectively.

This study showed that the classes of blood lipids in the neonatal calf are not changed markedly by wide difference in dietary fat. In the main lipid classes are cholesteryl esters and phosphatidylcholine and these are a circulating storehouse of essential fatty acids. It was also determined that a high dietary intake of linoleic acid can reduce arachidonic acid synthesis, and, in general, adipose fatty acid composition reflected dietary intake.

Urea treated corn silage (UCS) and protected feed protein

Bypass protein fed with UCS is an excellent dairy cattle feed. A concentrate containing fish meal and fed with UCS gave 6453 kg of milk in a 305-day lactation compared with 6185 kg when untreated corn silage (CS) and fish meal were fed. When soybean meal (SBM) was the chief protein source, milk yield with UCS and CS was 6007 and 5799 kg, respectively. All rations contained 15.5% crude protein (CP). Although fish meal is a good source of bypass protein, it is relatively costly and difficult to obtain in uniform quality. Attention has focused on SBM treated with 0.3% formaldehyde as a source of bypass protein to be fed in conjunction with UCS. Unprotected SBM gave better lactation yields when fed with UCS than did the protected SBM—32 versus 30 kg/day, respectively. Ration CP was 13.4% for both treatments. A negative control group at 12% CP gave 28.4 kg/day less milk. The group fed protected SBM, however, had greater weight gains over the 10-wk trial period than the other two groups. The failure of protected SBM to support superior lactation when fed with UCS lies in the selective destruction of some essential amino acids caused by the cross-linking reactions of formaldehyde. Amino acid analysis of protected SBM showed that the content of lysine and tyrosine was reduced by as much as 23 and 66%, respectively.

Feed protein degradation using rumen protease

Currently, the amount of bypass protein is detemined either by in vivo or in vitro methods. In in vitro methods, either whole rumen fluid or commercially available purified protease enzymes from nonrumen sources are used. Both methods have many disadvantages. Therefore, a standard in vitro method, using a stable preparation of proteolytic enzymes from mixed rumen organisms, was developed for the routine determination of rumen degradability of feed proteins.

The enzyme preparation has been used to test various feed proteins including soybean, linseed, and rapeseed meals, fish meal, blood meal, corn gluten meal and formaldehyde-treated soybean meal. For rates of degradation measured, the feed proteins ranked in the same order as reported in the literature for the other in vivo methods.

The new enzyme preparation eliminates the need to use freshly collected rumen fluid from donor animals with the resulting variability of microbial activity. The cell-free soluble enzyme avoids complications in the other assays because of reutilization of the products of feed protein hydrolysis for microbial protein synthesis. The availability of the stable enzyme preparation also makes results from different laboratories comparable.

Dietary effects on microbial protein production

Attempts to estimate dietary effects on rumen bacterial or protozoal populations have been frustrated by the large apparent variation in microbial numbers between animals. Animal-to-animal variation can be minimized by determining both bacterial and protozoal populations, calculating the regression between these two values, and using the regression equation to estimate a total microbial population at a standard bacteria-to-protozoa ratio. This estimation of microbial protein content in the liquid-small-particle phase of the rumen, combined with measurement of rumen volume and turnover rate, is a convenient means of determining microbial protein production in the rumen.

Distribution of β-glucanases in rumen bacteria

The cellulolytic rumen bacteria *Bacteroides succinogenes* and *Ruminococcus flavefaciens* contain β-glucanases that are specific for β-1,4 and β-1,3 glucoside linkages. These activities have been shown to reside in separate enzymes. Studies compared the cellular distribution of these two enzyme activities and showed that the β-1,4 and the β-1,3 glucanases are located in different areas in these two bacteria and that they serve grossly different functions.

SWINE PRODUCTION

Effects of deoxynivalenol (vomitoxin) on production

An experiment with 64 gilts and barrows from weaning to market weight determined the long-term effect of feeding vomitoxin-contaminated diets to pigs. When the diet contained vomitoxin at approximately 4.5 mg/kg, feed intake and consequently weight gain were reduced compared with a control diet containing no detectable vomitoxin. These differences in performance continued throughout the growing–finishing period and gave no indication that the pigs became accustomed to the contaminated diet. Metabolism trials with 35-kg barrows are currently determining nitrogen balance.

Differences between boars and gilts in their response to vomitoxin-contaminated diets are being examined. Preliminary results indicate little difference between the sexes, but both barrows and gilts eat less contaminated diet (with vomitoxin at approximately 3.5 mg/kg) than non-contaminated (control) diet and consequently weigh less at any age.

Other results are reported in the section entitled "Animal feed safety and nutrition."

Behavior and welfare of pigs

Some farrowing crates are designed with a lower horizontal bar, which seems to hamper the piglet's access to the udder. In other designs, this bar is replaced by a series of angled, vertical bars, which permit freer access to the teats. Two experiments, involving 87 litters, compared the performance of pigs in farrowing crates of each type. In both experiments, litters reared with vertical-bar crates had more uniform 14-day weights than those reared with horizontal bars. This finding suggested that unequal access to the udder associated with horizontal bars caused uneven distribution of milk intake.

Cloprostenol, an analogue of prostaglandin $F_{2\alpha}$, has gained substantial acceptance within the pig industry as a means of inducing farrowing in sows. Because of concerns about high body temperature of sows after induced parturition, an experiment was conducted with 161 sows. The farrowings were induced by the recommended single 175-μg dose of cloprostenol or a lower 125-μg dose, and saline-injected sows served as controls. There was no evidence of higher body temperature of induced sows as opposed to spontaneous farrowing. Both cloprostenol dosages gave successful synchronization of parturition, with most farrowings occurring within 29 h of injection.

A two-level, free-access pen has been designed for fattening pigs. The pen has an upper floor of solid concrete and a lower slotted floor, connected by a short ramp. The design allows efficient use of barn space, encourages good pen hygiene, and provides confined pigs with exercise. In experiments with 374 pigs being fattened, the performance and health of animals in two-tiered pens were compared with those of pigs housed in conventional pens offering the same total floor space all on one level. When the pigs were first moved into the two-tiered pens, they showed a small check in growth as they adapted to the new type of housing. Thereafter, weight gains, feed conversion, and physical condition were at least as favorable in the two-tiered pens as in the conventional ones.

Carcass evaluation

Research is being conducted to improve both the methodology and technology of hog carcass grading procedures. Two electronic measuring probes, the Danish Fat-O-Meater and the New Zealand Hennessy Grading Probe, were shown to be equally precise in predicting the cutability of pig carcasses. Further research is under way to determine the operational efficiency of these probes under abattoir conditions and to study the impact on the Canadian grading system of introducing an electronic probe into the abattoir.

A cooperative study with the Meat Research Institute (UK) investigated the growth and distribution of muscle, fat, and bone in the carcass of entire males and females of Large White, Pietrain, and Iron Age (European Wild Boar × Tamworth) breeding. The Iron Age pig represented the type of swine common to western Europe 2000 yr ago, which has been thought to be ultra lean. When compared at 90 kg, the percentages of muscle and fat for the Iron Age, Large White, and Pietrain breeds were 40.9 and 48.8%, 57.0 and 25.6%, and 61.1 and 22.6%, respectively. Back-fat measurement was 33.5 mm for the Iron Age compared with 10.2 mm for the Large White and 8.6 mm for the Pietrain.

POULTRY BREEDING

Selection and flock management studies in egg-laying chickens

Part record selection for hen-housed egg production was compared with similar selection for hen-day rate of egg production from age at first egg using two Leghorn strains derived from a common stock and selected for a similar complex of economic traits. In addition to egg production, selected traits included fertility, hatchability, viability, egg size, egg specific gravity, Haugh units, blood spots, and more recently, body weight. Over 10 generations, both strains improved in part-record egg production, but the rate-selected strain improved much more in full-year egg production. There was little evidence of change in heritabilities or genetic correlations, although there were real differences between the two strains.

A study of heterosis using two-way, three-way, four-way, and F_2 strain crosses as well as commercial and control strains revealed that heterosis for hen-housed egg production declined in three-way, four-way, and F_2 crosses as compared with two-way crosses. Expressed as a percentage of that of two-way crosses, heterosis for hen-housed egg production for three-way, four-way, and F_2 crosses was 84%, 54%, and 44%, respectively. Explanation for heterosis on the basis of dominance was rejected because under such a hypothesis heterosis of two-way, three-way, and four-way crosses would be expected to be the same.

Two flocks of Leghorns were used to compare the effects of comb removal (dubbing) at hatch, removal of both comb and wattles (dubbing and dewattling), and not dubbing or dewattling. Birds of several genotypes were assigned randomly to the three treatment groups and upon housing were assigned randomly to three caging formats: three hens per 31 × 41 cm cage, two hens per 25 × 41 cm cage, and two hens per 20 × 41 cm cage. Similar to earlier work, the effects of dubbing on performance were small and not influenced by genotype, but may be modified by caging format. Dubbing at hatch was superior to dubbing and dewattling at the later age of 130 days.

Genetics of poultry meat production

A synthetic broiler sire population was used for three generations to compare selection programs. Using two lines per program, the traits selected were high 28-day body weight and either low abdominal fat percentage at 47 days or high 28–42 day feed efficiency, or both of these traits. Indices were used to combine individual and full- and half-sib information for the two or three traits involved. For each generation, selected lines were reproduced by selecting the highest indexing 32 sires and 128 dams surviving at 42 wk from approximately 300 male and 300 female progeny hatched per line. The control line was maintained by selecting 60 sires and 180 dams based on one son per sire and one daughter per dam. Progeny of the four lines selected for low percentage of abdominal fat were slightly heavier and had less abdominal fat than corresponding controls. No consistent change in feed efficiency could be detected in progeny of lines selected for this trait.

Methods of adjusting age-constant (from 28 to 42 days) feed consumption and efficiency test data for differences in body weight were examined. The pedigree broilers tested represented broiler sire and broiler dam populations. Feed efficiency adjusted for differences in maintenance requirements caused by variation in body weights during testing, and feed consumption adjusted for differences in body weights, had heritability estimates that were similar to those derived from unadjusted traits. Correlations of the two adjusted traits with other traits differed in sign, as expected, but were otherwise similar. Selection for low feed consumption after adjustment for body weight during test may yield better response than selection for adjusted feed efficiency because of more consistent heritabilities of 0.4–0.5 for consumption versus 0.1–0.6 for efficiency in four different groups.

Prediction of broiler abdominal fatness by measuring the thickness of the abdominal wall was compared in two strains of broilers. One was a modern, synthetic broiler dam strain that grows rapidly and the other was the Ottawa Meat Control strain that grows half as quickly. Correlations between percentage of abdominal fat and thickness of the abdominal wall in the modern and the slow-growing strains were 0.02 and 0.16, respectively. Although the correlation for the slow-growing strain was larger than that for the fast-growing strain, it was still much smaller than the value reported in the literature (0.16 versus 0.8), which was also based on a slow-growing strain.

Carcass fatness

Techniques for determining carcass fatness were studied in slow- and rapid-growing strains of broiler chickens to 17 wk of age. Very low density plasma lipoproteins (VLDL), lipase activity of abdominal fat, and fatness were measured. Broilers of the rapid-growing strain had greater abdominal fat and percentage of carcass fat and less lipase activity of fat than those of the slow-growing strain but had the same amount of plasma VLDL. Compared with males, females were fatter and had more plasma VLDL than males with about the same amount of lipase

activity of fat. Abdominal fat, percentage of carcass fat, and plasma VLDL increased with age, whereas lipase activities of fat decreased with age. Lipase activity of fat because of its negative association with fatness during growth may be useful, as is plasma VLDL, as an indirect measure of fatness at a given age.

Disease resistance genetics

Laying hens of six two-way crosses of selected strains and two control strains were used to examine horizontal (infected by contemporaries) and congenital lymphoid leukosis virus (LLV) infection. Albumen samples were tested for the group-specific antigen of LLV, and yolk samples were tested for LLV using the phenotypic mixing test. Albumen-positive, yolk-negative hens were assumed to be horizontally infected, and those that were positive in both were assumed to be congenitally infected. The control strains and strain crosses had a similar incidence of horizontal infection (7.5 versus 8.8%, respectively), but the control strain had a greater incidence of congenital infection (13.3% versus 5.2%, respectively).

Egg production to 497 days of age in both horizontally and congenitally infected shedders was lower by 15 and 18 eggs, respectively, than that of non-shedders. In addition, egg quality was reduced and sexual maturity delayed. Congenitally infected shedders laid fewer and smaller eggs and matured earlier than horizontally infected shedders.

Management and genetics geese

Investigations of lighting regimens have shown that geese exposed to 10 h of light and 14 h of darkness (10L:14D) produce more eggs with greater fertility than those given 13L:11D and about the same number of eggs and fertility as those under 11L:13D. In a further study of lighting regimens, animals from a Chinese and a Synthetic (developed from Chinese, Pilgrim, and Hungarian breeds) strain of pullet geese were housed in December under 7L:17D. At the end of January, half the animals of each strain were exposed to 10L:14D and the rest were exposed to 12L:12D. After a spring laying season of 24 wk, Chinese geese given 10L:14D laid about the same number of eggs as those under 12L:12D (53 versus 51 eggs, respectively), whereas Synthetic geese exposed to 10L:14D laid considerably more eggs than those given 12L:12D (44 versus 24 eggs, respectively). Fertility was about the same for the Chinese geese but considerably greater for the Synthetic strain when exposed to 10L:14D compared with geese under 12L:12D. However, after a summer molt of 8 wk, geese of both strains exposed to 10L:14D came into production later and laid fewer eggs than geese given 12L:12D by the time of market 3 mo later.

Eggshell quality

The main circulating estrogen conjugates in laying hens are estradiol-17β-3-sulfate, estradiol-17β-17-sulfate, and estrone sulfate. Two thin-layer chromatographic systems were developed that markedly improved separation of these metabolites to allow investigation of their role in eggshell formation.

POULTRY NUTRITION

Direct measurement of the shell strength of hatching eggs

The puncture test is a practical direct method for measuring the material strength of eggshell. The test causes no apparent damage to the membranes under the puncture site. A study to determine the effects of the puncture test on egg hatchability indicated that one or two puncture measurements increased the hatchability of eggs from White Leghorn and broiler hens compared with eggs from these genotypes that were not punctured. An improvement of approximately 12% occurred when eggs from Leghorn hens were punctured once and 9% when those from broiler hens were punctured twice. Placing four punctures in broiler eggshells caused a decrease of approximately 11% in hatchability but had only a small effect (≈1%) on the hatchability of Leghorn eggs. The number of punctures per egg had little effect on egg weight loss during the first 18 days of incubation or on body weight gains and mortality between 1 and 21 days posthatching. Covering the puncture site with a small drop of beeswax decreased hatchability by 4.5% compared with nonpunctured control eggs. The addition, however, of one, two, or four drops of beeswax to nonpunctured eggs also reduced hatchability by 1.4%.

The use of naked oats in poultry nutrition

Studies on the use of naked oats were extended by an experiment in which the oats were included in broiler starter and grower diets at levels of up to 600 and 750 g/kg, respectively. The oats replaced corn, soybean meal, and tallow in a corn–soy diet, providing diets of equal true metabolizable energy (TME) and lysine content. Naked oats had an adverse effect on weight gain and feed intake during the starter period, the effect being greater for males than females. During the grower period (28–47 day of age) the oat diets performed

satisfactorily as previously reported and the inhibitory effect was diminished or absent. At slaughter the oat-fed birds contained less abdominal fat. It is concluded that in nutritional terms, naked oats are a suitable replacement for corn and soybean meal in broiler grower diets.

Feedstuff evaluation

Retained nitrogen (RN) is a useful estimate of protein synthesis or catabolism and plays a critical role in the evaluation of feedingstuffs. There are two widely used methods for estimating RN. The first is nitrogen balance, which is the difference between intake and excretion, and the second is comparative slaughter, whereby the carcass nitrogen gain is measured by comparing the carcasses of birds killed at the beginning and end of an experiment. Experiments showed that nitrogen balance usually gave larger values than comparative slaughter, but it was not possible to determine which estimate more closely estimated RN. Variation in carcass nitrogen concentration was greater in adult birds than in chicks, and consequently the precision of comparative slaughter data tended to decrease with age. Improved methods for estimating RN are required to monitor changes in the carcass compositions of living birds during growth and fattening.

Classical theory teaches that the efficiency of energy utilization varies with intake, so that the relationship between retained energy and intake energy is described by a curve. A simplification uses two straight lines intercepting at the point of zero energy retention. In a series of experiments with chicks and adult cockerels, there was no evidence of curvilinearity, and a single straight line adequately described the relationship. The work also confirmed that birds often gain protein and lose fat when retained energy is zero. Recognition of these relationships facilitates the estimation of energy requirements for various levels of productivity, which is critical because many nutrients are included in diets at specified ratios to energy.

Detailed analyses of incoming feed ingredients are usually too expensive and time consuming, and consequently, feed manufacturers rely on data banks for much of the information describing ingredient composition. For several years the Animal Research Centre has been publishing precise, accurate data for inclusion in such data banks. During 1984, extensive data describing Menhaden fish meal were distributed. The bioavailable amino acid values are of particular importance because fish meal is a major source of potentially high-quality protein. The quality is susceptible to processing variables, and so it was encouraging to note the uniformly high quality among all 15 samples assayed.

Adoption of the TME system of feed evaluation has been rapid and widespread. However, a failure to understand the fundamental relationships between estimates of bioavailable energy in feedingstuffs is the cause of some reluctance to change. A detailed theoretical explanation of the relationships, supported by extensive experimental data, was published. Of particular importance is the observation that TME_n values are only slightly greater than AME_n values measured at high levels of feed intake. Consequently, energy requirements expressed in terms of AME_n may be used in the TME_n system, and recognition of this should enable greater use of the system with the associated economic gains.

SHEEP PRODUCTION

Development of specialized, synthetic sire and dam strains

A study of growing rams of the synthetic and control strains showed that breed, birth date, age of ram, and body weight had important effects on the linear body measurements of heart girth (HG), body length (BL), leg length (LL), metacarpal circumference (MC), wither height (WH), and hook width (HW), whereas age of dam effects were absent. Significant effects of litter size on HG and BL were observed at 6 and 8 mo of age, respectively. Rams of the synthetic sire strain, with a large proportion of Suffolk background, were generally similar to Suffolk rams in all body measurements except for HG, which was significantly larger. Rams of the two synthetic dam strains, with 50% Finnsheep background, were similar in body measurements. The synthetic dam strains did not differ from either the synthetic sire strain or the Suffolk with respect to HG, BL, WH, and HW. However, Suffolk rams had larger MC and shorter LL compared with those of the two synthetic dam strains.

The Finnsheep rams had smaller HG, BL, MC, and HW than the synthetic and Suffolk rams, whereas LL and WH of the Finnsheep and Suffolk rams were similar. Linear body measurements were positively correlated with each other and with body weights; however, the relationship varied as rams matured. The importance of breed, birth date, age of ram, and body weight on body measurements and the requirements for appropriate adjustments were emphasized.

Further serological monitoring of 200 original, hysterectomy-derived ewes and 100 first-genera-

tion progeny for Maedi-Visna showed no positive reactors, providing additional evidence of the effectiveness of the hysterectomy procedure in eliminating specific diseases.

Intensive rearing of lambs

Lambs fed a high-energy postweaning diet with a calcium-to-phosphorus (Ca-to-P) ratio of 2.9:1 had significantly higher gains than those fed the same diet with a ratio of 0.8:1. The results also indicated that high levels of vitamin D, administered intramuscularly, were not beneficial when dietary levels were adequate to meet requirements. Serum Ca, P, or alkaline phosphatase were of little value as indices of nutritional status.

With the present artificial rearing system, many lambs do not readily accept the artificial teats, and they require training for 1–2 days before nursing independently. Behavioral research has shown that lambs are very sensitive to the firmness of the teat. Preliminary results indicated that soft rubber teats were accepted readily, whereas firm ones were initially rejected. When the texture was appropriate, the surface temperature of the teat had little influence on sucking behavior.

Carcass quality

Ultrasonic measurements of fat thickness and *m. longissimus* depth, 2.5 and 5.0 cm lateral to the midline at the last rib and 10 cm posterior to the last rib, were made prior to slaughter on 273 growing ram lambs using a Scanogram machine (Model 722, Ithaco Inc., Ithaca, N.Y.). Fat thickness measurements had no predictive value, whereas *m. longissimus* measurements increased the precision of carcass lean prediction above that obtained from weight at scanning alone. The residual standard error for the prediction of carcass lean from weight at scanning was 0.29 kg, whereas the addition of the muscle measurement reduced, at best, the residual standard error by 0.02 kg. It was concluded that ultrasonic measurements on the live ram lamb at 37 kg body weight are of questionable value for accurate prediction of carcass quality.

Reproductive physiology

Ewe productivity. A study evaluated the following: the effect of dose of pregnant mares' serum gonadotrophin (PMSG) on the reproductive performance of adult ewes and ewe lambs; and lamb survival at birth following treatment with intravaginal sponges impregnated with fluorogestone acetate (FGA) and treatment with a PMSG injection of 250 or 500 IU when the sponges were removed. The treatments were applied over three successive matings during repopulation of the minimum-disease flock. Ewes were exposed to rams at the synchronized and subsequent estrus. Overall, there was no effect of dose level of PMSG on the reproductive performance of adult ewes. Reproductive performance of ewe lambs was lower and there was a strain treatment interaction, suggesting greater variability in response. The results indicate no advantage to using the higher dosage of PMSG in ewes with a litter size that was naturally relatively high, which in this study was 1.7–1.8 in the sire strain and Suffolk breed and 2.4–3.0 in the dam strains and Finnish Landrace breed. Birth weight of lambs, lamb survival, and distribution of lambs according to litter size among adult ewes and ewe lambs were similar at both doses of PMSG. However, the average birth weight of lambs born as twins or triplets to ewe lambs was generally lower than that of those born to adult ewes.

A comparison was made between raddle markings and the presence of spermatozoa in vaginal smears as a method of predicting which ewe will lamb. The presence of spermatozoa in vaginal smears 48 and 72 h after introduction of rams following induction of a synchronized estrus improved the accuracy of predicting ewes that subsequently would lamb over predictions based on ewes raddled during 12-h intervals from 0 to 72 h after sponge removal. This improvement resulted from a reduction in the number of ewe lambs predicted to be bred that failed to lamb and a substantial reduction in the number of mature ewes not predicted to be pregnant that subsequently lambed.

Follicular growth and ovulation. Studies on factors controlling preovulatory follicular growth and ovulation continued, using the prepubertal gilt treated with hormones to induce preovulatory follicular growth and ovulation, as an experimental model. Isolated and dispersed granulosa and theca interna cells from maturing follicles, incubated for up to 6 h in a chemically defined medium, have the capacity to produce prostaglandin E_2 (PGE) and prostaglandin $F_{2\alpha}$ (PGF) as measured by radioimmunoassay. The production of PGE and PGF by both cell types increased markedly with follicular maturation. This increase parallels the pronounced rise in follicular fluid levels of prostaglandins associated with follicular rupture and ovulation and provides convincing evidence that the prostaglandins in follicular fluid are of intrafollicular origin.

Artificial insemination. A study with ewe lambs 6.5–7 mo old, inseminated once with 450×10^6 spermatozoa at 55 h or twice at 55 and 60 h, after synchronization of estrus with fluo-

rogestone-acetate-impregnated sponges and PMSG, showed no effect of number of inseminations on fertility. However, body weight at breeding had an important influence on reproductive performance. Ewe lambs that were at least 67% of adult weight had better fertility and produced more lambs. Fertility, litter size, and fecundity for the heavier lambs were 48%, 2.0, and 1.0, respectively compared with 68%, 2.4, and 1.6 for similarly treated adult ewes. Embryonic mortality contributed to the reduced fertility of ewe lambs.

Studies on the optimum conditions for preservation of ram spermatozoa continued with an examination of the three-way interaction of diluent osmolality, freezing rate, and glycerol concentration. Diluents with osmolalities of 450 and 600 mOs/kg provided the optimum environment for spermatozoa protected with 4–6% glycerol and frozen at rates of 10–100°C/min in 0.5-mL plastic straws. Although the 450 mOs/kg diluent was superior to that at 600 mOs/kg at slow cooling rates, even the best survival at this rate was low and therefore of no practical value.

The effect of thawing rates on survival of spermatozoa in semen frozen in straws at the optimum rate of 20°C/min or at a suboptimum rate of 2°C/min was studied. For semen frozen at 20°C/min, the best spermatozoa survival was obtained with fast-thawing rates produced by submerging the straws into a 60°C or 80°C water bath for 8 or 5 sec, respectively. Similarly, for semen frozen slowly at 2°C/min the spermatozoa tolerated the fast thawing rates and a slow-thawing rate produced by exposing straws to room temperature (~20°C), but survival was always lower than when semen was frozen at the optimum rate. Moreover, the thawing velocity produced by immersion of straws in a 20°C water bath was lethal to spermatozoa in semen frozen slowly.

Manipulation of photoperiod. Studies on the long-term effects of various artificial photoperiods on maintaining year-round, high-quality semen in rams have continued. Weekly measurements of testis size, semen quality, and blood hormone levels indicate that during short-day photoperiod treatment, scrotal size, sperm motility and concentration, seminal plasma fructose and citric acid levels, and blood testosterone increased. During periods of long days, these parameters decreased. When photoperiod treatment comprised brief periods or no exposure to long days, changes in scrotal size and semen quality were minimized.

ANIMAL FEED SAFETY AND NUTRITION

Pesticide metabolism

Deltamethrin. Studies on the metabolic fate of deltamethrin (decamethrin, Decis, NRDC-161, RU22974) in Leghorn hens were completed. Each hen received 7.5 mg of ^{14}C-labeled (*gem*-dimethyl or benzyl) deltamethrin, which was equivalent to approximately 50 mg/kg of daily ration for 3 days followed by a no-treatment period of 5 days. Postdosing excreta and eggs were collected on a 24-h basis. The hens were killed at 6, 18, 48, and 120 h after the last dose and samples of liver, kidney, heart, subcutaneous abdominal fat, breast, and leg muscles were collected. About 83% of the aministered ^{14}C was eliminated during the first 24 h after dosing, while approximately 92% of the total administered radioactivity was eliminated within 18–24 h after the last dose. Tissue residues were generally very low (~10 μg/kg), with the exception of those for liver, kidney, and ovarian yolk. Hens killed 18 h after the last dose had the highest levels of residues, which for kidney, liver, and ovarian yolk were 4.54, 2.54, and 2.32 mg/kg, respectively. In laid eggs, the yolk contained considerably higher residues than albumen (0.58 versus 0.19 mg/kg, respectively). Residue levels in all tissues, organs, and eggs decreased quickly after dosing was discontinued. In general, residues derived from the *gem*-dimethyl portion of the molecule tended to be higher than the benzyl moiety. Large numbers of metabolites were isolated from excreta and identified by a combination of chromatography and spectroscopy techniques. Metabolites were presented in both free and conjugated forms. The nature of metabolites identified indicated that the metabolic pathways of deltamethrin in laying hens are complex.

Cypermethrin. Studies were initiated in laying hens on the fate of cypermethrin and its metabolites *cis*- and *trans*-3-(2,2-dichloro-vinyl)-2,2-dimethylcyclopropanecarboxylic acids with the aid of ^{14}C-labeled materials. About 90% of the administered ^{14}C from each preparation was eliminated in excreta within 24 h. Only small quantities of ^{14}C were retained in various tissue organs and eggs.

Mycotoxins

The persistence of fungi-produced toxins (mycotoxin) in animal feedstuffs and the possibility for the introduction of these mycotoxins

into the human food chain continue to raise serious concerns in terms of animal and human food safety. Recent levels of vomitoxin (deoxynivalenol, DON) in eastern Canadian grains have not been as high as reported earlier. However, trace concentrations of *Fusarium* metabolites such as T-2 and HT-2 previously not identified in these grains were found in isolated areas. The presence of other toxins in contaminated grains may indicate that many of the problems with livestock, especially swine, are not caused by vomitoxin alone, but are due to synergism of two or more mycotoxins or other contaminants that may be more toxic than DON at low concentrations in the milligrams-per-kilogram range.

Results of feeding trials using contaminated feeds and dose–response studies using purified DON indicated that swine were very sensitive to DON-contaminated feeds. Results indicate that swine eat less of a feedstuff containing low levels of DON than clean feed. Reduced feed intake as an initial response was observed in pigs fed DON-contaminated diets with levels of 0.3–0.5 mg/kg. No serious adverse effects such as toxic symptoms or organ damage were seen at DON levels of < 2 mg/kg in diets for growing–finishing hogs and sows or gilts during pregnancy and lactation. Poultry and ruminants such as dairy cattle showed no major adverse effects when their diets contained DON levels up to 5 mg/kg, other than a small decrease in egg and shell weight and some other measures of shell strength. Residue studies indicate that DON is not transmitted to edible animal products such as eggs or milk when dosed with toxin levels considerably higher than normally occurs in contaminated feedstuffs.

Studies with sheep to establish the metabolic fate of DON showed that only 7.5% of the mycotoxin is absorbed into the blood following oral ingestion. This was partly the result of the rapid and efficient metabolism of the toxin by rumen microorganisms. Systemic DON was found to undergo extensive hepatic metabolism and was rapidly eliminated.

Rapid and sensitive methods for the quantitation of DON and other *Fusarium* mycotoxins have now been developed for animal feeding trials.

Fats and oils

A retrospective statistical analysis of data from over 2800 albino male rats fed semisynthetic diets containing various vegetable oils, examined the relationship between body weights and incidence and number of myocardial lesions. The results showed that for a given diet, rats with lesions were heavier by 15.6 g than those without lesions. Those with three or more lesions in the heart were heavier by 15.4 g than those with one or two lesions. The differences applied to all diets, irrespective of the level and type of fat.

As part of fats and oils research, new and improved methods of fatty acid analysis are being developed. The new crosslinked or bonded (or both) fused silica capillary columns were examined to determine whether stabilization affected the chromatographic behavior of polyunsaturated fatty acids. Bonding and crosslinking polyethylene glycol phases increase the column polarity, which improved separation of a number of polyunsaturated fatty acids.

Two major documents were prepared in support of Agriculture Canada's petition to the US Food and Drug Administration (FDA) to permit the use of low erucic acid rapeseed (LEAR) oil in infant formulas. All the scientific data pertaining to the energy and essential fatty acid requirements of infants were reviewed. Based on the limited information on the fat requirements of infants, it was recommended to the FDA and to Health and Welfare Canada that all vegetable oils, including LEAR oils, be re-evaluated as to their nutritional efficacy in infants.

BIOTECHNOLOGY

Embryo manipulation

Embryos are a logical target for research to improve livestock performance. By embryo transfer, multiple calves can be obtained from a single cow, allowing evaluation of genetic potential and estimation of nonadditive genetic effects on performance. If bisected or split embryos are transferred, identical twins or multiplets can be produced, permitting an assessment of the effect of uterine environments and minimizing genetic variation. The techniques for embryo manipulation in laboratory animals are being acquired and will be applied to research on cattle and sheep.

Rat embryos of the Wistar strain and its F_1 cross (Wistar females mated with Brown Norway males) were transferred nonsurgically to 48 Wistar, 17 F_1 cross and 20 Wistar-Imamichi recipients. Embryos of each type were transferred together to each recipient to compare embryo viability. The pregnancy rate for both types was 78.8%. The survival rate of fetuses to term was 11.5% and 25.1% for the Wistar and F_1 embryos, respectively. Placental weight differed significantly between embryo types and among recipient types, whereas fetus weight differed only among recipient types. There was a significant interaction between recipient and embryo types.

It was concluded that the F_1 cross embryos were twice as viable as Wistar embryos.

Embryos were collected from donor mice that were killed about 70 h after copulation. The number of embryos collected per donor averaged 6.8 from 259 mice. Embryos at the early, morula stage of development were bisected and cultured overnight in Bigger's medium mixed with bovine fetal serum. It was found that 40% of the bisected embryos developed to blastocysts that were ready for transfer to recipients; when they were transferred, 54% grew in the uteri. Production of twins is under way to examine their growth and performance. All mouse embryo transfers were accomplished nonsurgically.

Genetic manipulation of rumen bacteria

Genetic engineering techniques are being used to increase the level of the limiting essential amino acids, lysine, methionine, and threonine, in the bacterial protein produced in the bovine rumen. The first synthetic gene produced and transferred, designed to direct the synthesis of a polypeptide containing equal amounts of lysine, methionine, threonine, and leucine, was lethal to the host bacterium. Five new synthetic genes, designed to determine the cause of this lethality, have been assembled in vitro. If transfer of these genes to rumen bacteria is successful, it should result in new strains capable of providing the ruminants with the limiting amino acids.

The control of gene expression in rumen microorganisms is being investigated by cloning rumen bacterial genes in *Escherichia coli*. Six β-gluconase genes from the fiber-degrading rumen bacterium *Bacteroides succinogenes* were cloned in *E. coli*. In a clone examined in detail, the regulation of expression of the rumen bacterial gene in *E. coli* is the same as in *B. succinogenes*, showing that gene transfer between these two organisms is feasible. However, differences in the posttranslational modification of the protein indicate that not all genes would be expressed equally well in the two organisms.

Disease resistance genetics

Lymphoid leukosis is a lymphoproliferative disease of chickens caused by retroviruses. There are several exogenous virus subgroups and one subgroup is endogenous. The proviral DNA that codes for the production of the endogenous virus forms a permanent part of the genome of most chickens. Cooperative research with the U.S. Department of Agriculture laboratory in East Lansing, Mich., and the Animal Diseases Research Institute of Agriculture Canada investigated production of the complete endogenous virus in three strains of chickens. The assay procedures satisfactorily detected the presence of the exogenous and endogenous viruses as well as the presence of a group-specific viral antigen. This antigen normally forms a part of both the exogenous and endogenous virus particle. It could also be produced from the endogenous provirus, even though the complete endogenous virus is not produced. In the ARC strains tested, the incidence of production of a complete endogenous virus was low, but an endogenous group-specific antigen was produced by a much higher proportion of birds in the populations.

Eggs were imported from the U.S. Department of Agriculture research laboratory for a Leghorn line of chickens that does not possess any endogenous provirus DNA and is also genetically resistant to infection with the endogenous subgroup E virus. The line is now housed in an ARC quarantine facility and will be maintained for further disease-resistance studies.

To determine the relationship of immune potential to disease resistance, adult chickens of 23 genetic groups were injected intradermally with a small dose of phytohemaglutinin (PHA) in phosphate buffered saline (PBS). The swelling of the injection site is an indication of cell-mediated immune response. Correlations were estimated between the swelling index expressed as the difference between the swelling of the PHA- and the PBS-injected wingwebs on one hand and resistance to Marek's disease, a viral disease of chickens, on the other. The correlations were mostly negative. This indicated that high cell-mediated response relating to high proliferation of T-cells is associated with susceptibility to Marek's disease.

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London Research Centre, London, Ontario

PROFESSIONAL STAFF

H.V. Morley, BSc, PhD	Director
J.A. Coleman	Administrative Officer
D.E.H. Drew,[1] BSc, MLS	Librarian

Mode of Action of Selected and Potential Insect Control Agents

W. Chefurka,[2] BSc, MSc, PhD	Section Head; Biochemistry
E.J. Bond, BSA, MSc, PhD, DIC	Fumigation—toxicology
C.J. Bolter, BSc, MSc	Fumigation—toxicology
T. Dumas, DCE, MSc	Analytical chemistry
R.M. Krupka, BA, MA, PhD	Biochemistry
T.T. Lee, BSc, PhD	Plant biochemistry and tissue culture
T. Nagai, ME, MSc, DSc	Neurophysiology
E.B. Roslycky, BSc, MSc, PhD	Microbiology
A.N. Starratt, BSc, PhD, FCIC	Chemistry—attractants and repellents
R.W. Steele, BSc, PhD	Neurochemistry
A. Vardanis, BSc, MSc, PhD	Biochemistry

Mode of Action of Selected and Potential Plant-Pathogen Control Agents

E.W.B. Ward, BSc, MSc, PhD	Section Head; Pathology—phytoalexins
D.A. Cuppels, BA, MS, PhD	Phytobacteriology—microbial physiology
G. Lazarovits,[3] BSc, MSc, PhD	Plant pathology—fungicides
C. Madhosingh, BSA, MA, PhD	Microbial biochemistry and pathology
D.M. Miller, BSc, MSc, PhD	Biophysics—fungicide selectivity
A. Stoessl, BSc, PhD, FCIC	Chemistry—phytoalexins and mycotoxins
G.A. White, BA, MSc, PhD	Biochemistry—fungicides

Soil Pesticides

C.R. Harris, BA, MA, PhD	Section Head; Insect toxicology
B.T. Bowman, BSA, MSc, PhD	Soil physical chemistry
R.A. Chapman, BSc, MSc, PhD	Analytical organic chemistry
D.G.R. McLeod, BSA, MS, PhD	Physiology
J.R. Robinson, BSA, MSA, PhD, FCIC	Photodynamic insecticides
J.H. Tolman, BSc, MSc, PhD	Applied entomology
A.D. Tomlin, BA, MSc, PhD	Pesticide ecology
C.M. Tu, BSc, MSc, PhD	Microbiology
S.A. Turnbull, BSc, MSc	Toxicology

VISITING SCIENTISTS

National Research Council of Canada visiting fellows

H. Gousseau, BSc(Hon), PhD	Plant pathology
R. Parekh,[4] BSc, MSc, PhD	Microbiology
F. Rutherford, BSc, PhD	Plant pathology

Graduate students

M.K. Bhattacharyya,[5] MSc	Plant pathology
D. Classen, MSc	Plant pathology

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[1]Seconded from Libraries Division, Finance and Administration Branch
[2]Transfer of work October 1984–March 1985, Russel Grimwade School of Biochemistry, University of Melbourne, Australia.
[3]Transfer of work September 1984–September 1985, Agricultural Research Organization, Israel.
[4]Seconded from Faculty of Engineering Science, University of Western Ontario, London, Ont.
[5]Commonwealth Scholar.

INTRODUCTION

This report summarizes highlights of research carried out during 1984 at the London Research Centre in support of departmental objectives in environmental quality and crop protection. The center was established in 1951 to investigate the problems created by the introduction of synthetic organic pesticides.

Present research programs reflect the current health and environmental concerns regarding the agricultural use of pesticides by concentrating research efforts in integrated pest management (IPM) and environmental toxicology.

The IPM objective comprises four research activities. The pest management activity is aimed at developing IPM procedures, including biological control, for agriculturally and economically important insect pests. Research on stored products is directed toward the investigation of environmental and insect resistance problems and the development of more efficient fumigation procedures leading to a minimum of pesticide residues. The third activity concerns research on alternative pest control strategies. Studies on insects are aimed at identifying specific areas for attack, so that pest control in the future will not rely upon the use of broad-spectrum toxicants. Research on natural plant defense mechanisms in disease-resistant and susceptible agriculturally important crops has the objective of using natural defense mechanisms by biotechnology, chemical manipulation, or the breeding of resistant varieties.

The last activity under the IPM objective concerns research on systemic fungicides. Studies are carried out on the efficacy of systemic fungicides and on the plant pathological, biochemical, biophysical, and structural parameters of fungicide activity and resistance.

Research on environmental toxicology has three areas of activity. The first deals with the effect of pesticides on nontarget soil invertebrates and agriculturally important soil microorganisms. The second is concerned with the determination of the behavior, persistence, and environmental fate of pesticides and their movement through the environment. The third is concerned with establishing the mode of action of growth regulators and toxicants by carrying out studies on insects and plants related to vital processes of growth and development.

In December, at a news conference at the center, the Hon. John Wise, Minister of Agriculture, announced that spending authority had been obtained for the federal purchase of the 26.97-hectare parcel of land selected from over three dozen possible sites examined. This land is urgently required for expanded field research and for relocation of the downtown rented office–laboratory complex housing the Soils Pesticides Unit.

This report records only the highlights of our accomplishments for 1984; more detailed information can be obtained from the publication titles listed at the end of this report. Copies of this report, reprints of publications, and further information are available on request from the Research Centre, Agriculture Canada, University Sub Post Office, London, Ont. N6A 5B7.

H.V. Morley
Director

INTEGRATED PEST MANAGEMENT

Biological control of the onion maggot

Laboratory studies on the biology of the staphylinid beetle *Aleochara bilineata* (AB) continued. Long-term studies of diapause induction in AB were completed. Other studies were carried out on developmental threshold temperatures for several life stages, the effect of temperature on egg development, and the effect of age and density of host onion maggot pupae on parasitism by AB.

As a result of windstorms and torrential rainstorms early in the growing season, limited progress was made on the feasibility field studies aimed at incorporating biological control using parasites and predators in an integrated control program. The planned release of 0.5 million laboratory-reared AB in the field had to be severely curtailed because of adverse weather. Microplot field experiments indicated that AB populations of 1–32 beetles per square metre were as effective as chlorfenvinphos 5G in reducing onion maggot damage to onions early in the season. Although crop protection specialists have long recognized the fact that chemical efficacy is influenced by environmental conditions, it is becoming apparent that biological control methods will be even more susceptible to unpredictable natural phe-

nomena. A successful mass-rearing technique for the anthomyiid predator *Coenosia tigrina* (CT) has been developed, permitting the initiation of a comprehensive toxicological assessment of this beneficial insect. Three field cultures of CT were obtained and successfully reared for screening tests. Laboratory studies on the biology of CT were initiated.

Work continued on the entomogenous fungi *Entomophthora* sp. with the acquisition of numerous cultures from outside Canada to compare with the pure culture of *E. muscae* obtained from diseased onion maggot flies by laboratory culturing on an artificial medium. Studies continue on the investigation of the factors governing the invasiveness of infective conidia.

Monitoring

Extensive tests of corn borer pheromones were carried out, in cooperation with Lethbridge Research Station, and tests of common armyworm and fall armyworm pheromones were conducted in cooperation with Laval University. Variegated cutworms were monitored with sticky traps as opposed to funnel traps.

Populations of cabbage maggot flies in rutabagas, under grower field conditions, were found to be very low, but larvae caused significant losses. Yellow water-pan traps baited with allylisothiocyanate (ASCN) were effective for monitoring second- and third-generation cabbage maggot flies. Cone traps with ASCN were ineffective.

Studies on toxicity resistance

In studies on insecticide resistance, tests done on cabbage maggot submitted from Newfoundland gave no evidence of resistance to fensulfothion or carbofuran, even though efficacy data indicate that control programs with these insecticides are failing. The first reported case of pyrethroid resistance by the Colorado potato beetle in Ontario was confirmed on a strain submitted from the Thedford Marsh. Baseline data obtained on the pyrethroid-resistant potato beetle strain from Quebec indicated 23- to 38-fold resistance levels as compared with the susceptible London strain.

A study was carried out to determine the effect of dilution of a pyrethroid-resistant strain of house fly with a single introduction of susceptible flies. Results indicated that there was a rapid decline in resistance levels in the F_1 and subsequent generations.

Evaluation of pesticides

In the screening program, the spectrum of activity of three experimental insecticides was determined. SD208304 and TF5290 showed promise as soil insecticides. Insecticides currently registered or proposed for corn rootworm control were tested in primary and secondary bioassays against the black cutworm (a secondary pest of corn); several were effective, including Dowco 429X, SD208304, and TF5290. A soil bioassay procedure to determine the effect of insecticides on first-instar onion maggot was developed to complement the existing battery of tests in the screening program.

In the second year of the study on the persistence and degradation of insecticides recommended in Ontario for corn rootworm control, the persistence of 14 treatment-material combinations was evaluated under field conditions.

Chlorfenvinphos, chloethocarb, and CGA73102, which had shown limited persistence in 1983 were not included in 1984. Fensulfothion, trimethacarb, and two experimental insecticides were added to the list of seven insecticides carried over from 1983. Comparison of persistence data for those insecticides tested showed that all materials were less persistent in 1984. Climatic conditions appear to be a factor, and microbial adaptation also is being examined. The re-treated carbofuran soil was known to be adapted to degrade carbofuran, but carbofuran degradation in previously untreated soil was equally quick. Isofenphos, the most persistent insecticide tested in 1983, was the least persistent of the insecticides tested in 1984, and further examination revealed that soil adaptation had occurred.

Insect rearing

A vigorous insect-rearing program is a vital component of integrated pest management research. Development of successful techniques for rearing potential biological control agents is a prerequisite for inundative field release. Many insecticide-resistant and insecticide-susceptible strains are maintained and made available to other laboratories.

Forty-seven separate strains of insects representing 22 individual species were processed through the 1984 rearing program. A mass-rearing technique for the predator *Coenosia tigrina* was developed.

Thirty-three separate shipments of insects were made to a variety of government, university, and commercial laboratories across the country.

STORED PRODUCTS

Concern over the impact of the banning of ethylene dibromide on the status of the remaining fumigants led to an increased emphasis on methyl bromide (MeBr) in 1983 with regard to levels remaining after fumigation and the nature of the terminal residues.

Desorption studies showed that 93% of the applied MeBr desorbed from treated wheat and rapeseed after the first 30 h; 95% was lost from treated corn after 5 h. Grinding the sample doubled the desorption losses. The MeBr residue levels 14 days after treatment were less than 0.43×10^{-6}g in all cases. Analytical methodology, using a newly purchased photoionization detector, proved to be 3000 times more sensitive than the technique previously used. Levels down to 10×10^{-9}g could be measured.

Other experiments were carried out on yellow seed corn to determine residue levels after multiple fumigations with MeBr and the nature of the terminal products using ^{14}C-labeled MeBr. A large proportion of the residue was found in the germ portion of the seed; on a weight-to-weight basis, residues in germ tissue were seven times those found in the endosperm. Work still continues on developing analytical methodology for the various end-products. Most of the nonvolatile residue from ^{14}C-MeBr treated corn has been found to be associated with the protein fractions.

ALTERNATIVE PEST CONTROL STRATEGIES

Plant diseases

Research in this area is directed toward an appreciation of the basic processes occurring in plant–pathogen interactions in resistant and susceptible crops. The potential benefits of these studies would be the ability to activate the plants' natural defense mechanisms and to provide guidelines for breeding for genetic resistance.

It was demonstrated that soybean leaves display the same type of genetically controlled resistance responses to infection with *Phytophthora megasperma* f. sp. *glycinea*. The relative ease of observation and access to host–pathogen interaction through the leaf intercellular spaces suggests that the use of leaves will have many advantages in the study of the biochemistry of the disease and its manipulation. An additional potential advantage is that leaves may provide a screening method of great value to the plant breeder. The reaction to several races of the pathogen could be assayed at one time, and the plant could still be grown to maturity and the seed collected. In current methods only one race can be evaluated per plant, and plants are destroyed.

A reliable chemotactic assay system for *Pseudomonas syringae* pv. *tomato* (bacterial speck) was developed. This assay system will allow studies to be carried out on the response of the bacterial speck pathogen to chemotactic stimuli and hence is expected to lead to a better understanding of the role of chemotaxis in plant pathogenesis.

Of particular interest was the successful transposition Tn5 mutation (through scattered insertion) of the *P. syringae* pv. *tomato* chromosome. This powerful and direct biotechnological approach to explaining gene function should facilitate genetic analyses of virulence factors in this important plant pathogen.

The study of metabolites produced on synthetic media by the peanut pathogen *Cercospora arachidicola* was completed. It was demonstrated that under laboratory conditions large quantities of dothistromin, a known mutagen, were produced together with small amounts of seven other anthraquinonoid pigments. These products have been identified and are either known to be zootoxic or are presumed to be so because of their structures. The study also led, quite serendipitously, to the isolation of a mixture of 12 long-chain fatty aldehydes. This is the first report of the production of long-chain aldehydes by any fungus. One unusual feature of this mixture of fatty aldehydes was the predominance of odd-numbered carbon chains.

A collaborative study with Oklahoma State University has led to the discovery that at least one of the cadimane metabolites of cotton is biosynthesized by a mechanism other than that long accepted for the important toxin gossypol.

Fusarium pathogens are responsible for a large component of the annual losses due to diseases in tomato. In an attempt to obtain an understanding of the field behavior of the pathogen, auxotrophic mutants of the pathogenic and virulent isolates of *Fusarium oxysporum lycopersicae* and *F. oxysporum radicislycopersicae* were obtained. These will be used to characterize the behavior of genetic factors responsible for pathogenicity and virulence.

Insect pests. Research in this area is directed toward gaining an understanding of basic life processes peculiar to the insect so that methods of selective, specific control can be developed that do not rely upon broad-spectrum toxicants.

Research continued on the biochemical control mechanisms associated with the insect molt–intermolt cycle. Work in 1984 was highlighted by

the finding that a cyclic-AMP binding protein in an extract of newly molted adult grasshoppers had protein kinase activity. This activity had escaped detection previously because of its extreme lability. This enzyme is the fourth species of cyclic nucleotide-activated protein kinase isolated in this laboratory. This recently isolated enzyme has an interesting property that distinguishes it from the other three species.

A more complete understanding of the inactivation of proctolin by enzymes in cockroach hemolymph has been obtained. Insect hemolymph was shown to contain a very wide spectrum of peptidases including aminopeptidase(s), two dipeptidases, and an atypical postproline carboxypeptidase. It is now clear that three primary hydrolytic pathways, varying in importance with pH, account for the in vitro metabolism of proctolin in cockroach hemolymph. Several secondary and tertiary degradation pathways were also identified.

Studies have shown that a proprietary product sold for the preparation of HLPC-grade water is useful for the isolation of proctolin and other physiologically active materials from cockroach tissues. It is anticipated that the use of this resin will facilitate the isolation of sufficient quantities of the novel myotropic peptides in the cockroach nervous system for structural studies. The newly discovered inhibitory neuropeptide, neutrolin, isolated from cockroach tissues in this laboratory has also been identified in locusts.

ENVIRONMENTAL TOXICOLOGY

Environmental fate of pesticides

Work directed toward determining the movement and persistence of pesticides in the environment continued. Some newly designed field leaching units for studying pesticide mobility in soil cores were in operation in 1984. The apparatus allowed the quantitative collection of effluent from soil cores following rainfall. Results demonstrated that approximately two-thirds of incident rainfall on bare soil cores was lost by evaporation. Less that 6% of applied granular aldicarb was leached (as its sulfoxide or sulfone metabolites) through 38 cm in soil cores and by 36 cm of rainfall over a 14-wk period. No aldicarb or its sulfoxide or sulfone remained in the soil after 14 wk. Applied granular chlorpyrifos was totally immobile in the soil cores, and its persistence was inversely proportional to soil moisture content. Work on the persistent crop uptake and potential for groundwater pollution of selected soil insecticides continued. Methamidophos disappeared rapidly from sand and muck soils, indicating that there would be little chance of its leaching to ground water. Residues in radishes were below 0.005 mg/kg. Dowco 429X disappeared more slowly; after 16 wk in a sandy soil less than 1% remainded; in a muck soil after the same period of time approximately 10% remained. Residue levels in radishes and carrots were all less than 10 S84g/kg. Another experimental material, PP993, was also found to be moderately persistent. After 8 wk 10% of the applied level remained in a sandy soil and 23% in a muck soil. Residues in crops were at the 10 S84g/kg level or less.

Extensive research was carried out on a variety of pesticides and experimental conditions to examine the phenomenon of enhanced microbial degradation in adapted soils. In connection with the enhanced carbofuran degradation described in last year's report, it was felt that the whole question of soil activation to carbofuran, particularly in the area of corn rootworm control, could be better assessed if field workers had a reliable, easily performed test available. A simple colorimetric procedure was developed to test for adaptation of soil microorganisms to the degradation of carbofuran. One hundred and sixty-two pure isolates were screened for carbofuran degrading activity. Results obtained by HPLC analysis of the water soluble metabolite indicated that only one isolate, a *Streptomyces* sp., was active in degradation of carbofuran in activated soil.

Pesticide toxicity and mode of action

Investigations on the mode of action of photodynamic insecticides continued. One generally accepted theory ascribes toxicity to the formation in vivo of a highly activated form of oxygen (singlet oxygen) that disrupts vital biochemical processes. Experimental proof of this theory of in vivo action is lacking.

With the use of housefly larvae in vivo and a new improved experimental approach, it was found that dietary β-carotene affords partial protection from the photodynamic action of erythrosine. As the carotenoids are quenchers of known singlet oxygen processes, this result suggested that at least part of the phototoxicity is due to singlet oxygen. The situation is complicated by the unexpected finding that other dietary antioxidants not only failed to protect but actually resulted in enhanced phototoxicity. Apparently more than one mechanism contributes to the complex mode of action of the photodynamic insecticide erythrosine.

A basic requirement of the effective use of pheromones in IPM is to develop an understand-

ing of pheromone reception systems in insects. Electrophysiological studies on antennal responses (EAG) of the European corn borer to pheromones continued. In order to determine the ionic basis of EAG responses, a totally new perfusion technique was devised that allowed modified saline perfusion through the haemolymph space in the antenna. It was clearly demonstrated that the bioelectrical potential has its origin in the epithelial layer, where all receptor units are located. The results also demonstrated the unique pattern of the local response summation of stimuli. Direct evidence was obtained that the summation of the locally elicited EAGs contributed to the overall response. Studies on mode of action of fungicides, especially in relation to resistance problems, continued. A previous structure-activity study with a variety of *Thiophene carboxamides* and the succinate dehydrogenase complex or complexes (SDCs) from wild-type and mutant carboxin-resistant strains of *Ustilago maydis* revealed a number of molecular structures that showed specificity for mutated SDCs from highly and moderately carboxin-resistant SDCs. Molecular selectivity for mutated, carboxin-resistant SDCs can be influenced by replacement of an oxathiin (carboxin) by a thiophene heterocyclic ring and by the substitutive group on the amide nitrogen, allowing various categories of mutant types and mutants within a single category to be differentiated from one another.

Current work with thiophene carboxamides, and wild-type and carboxin-resistant mutated SDCs from *Aspergillus nidulans*, showed that a wide variety of structures showed negative activity correlation to the parent anilide, particularly with the SDC from a moderately carboxin-resistant strain of *A. nidulans*. On the other hand, no oxathiin carboxamides showed such negative activity correlation as they do with the SDCs of carboxin-resistant mutant strains of *Ustilago maydis*.

Data were obtained on the identification of thiophene carboxamide structures fungicidally active against several non-basidiomycete plant pathogenic fungi. A few thiophene carboxamides may be of practical significance against *Phytophthora infestans*. Greenhouse experiments have revealed that compounds such as the 3′*n*-butyl analogue of 3-methylthiophene-2-carboxanilide provided satisfactory protection against late blight of tomatoes.

Many measurements of the partition coefficients of biologically active compounds between aqueous and lipoid phases have been reported. These coefficients describe the distribution of the compound between the two phases under conditions of thermodynamic equilibrium. Such conditions are seldom attained by compounds passing through either plants and animals, or indeed the environment. A quantity much more useful to pharmacodynamics is the rate constant for the transfer of the compound between the phases—a quantity that has seldom been measured because of the complexity of the experimental methods. A fairly rapid and reproducible rate-measuring technique has been developed that requires relatively small amounts of materials, and its use has been demonstrated in the measurement of the rates of transfer of tritiated water and the lower alcohols in both directions across the water-octanol interaction.

Research continued on the mode of action of the herbicide glyphosate. An effective HPLC method was developed for the isolation and quantification of the major conjugates and oxidation products of the plant hormone indole-3-acetic acid (IAA). The 1983 finding of significant differences in the rate of IAA metabolism between glyphosate-tolerant and glyphosate-susceptible plant species led to kinetic studies of IAA metabolism. It was shown that the rate of conjugation of IAA affected by glyphosate was correlated with the inhibition of growth.

The involvement of IAA in glyphosate action was also demonstrated by the glyphosate-induced release of lateral buds from apical dominance and the decrease of ethylene production.

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Delhi Research Station, Delhi, Ontario

PROFESSIONAL STAFF

P.W. Johnson, BSA, MSc, PhD	Director
E.G. Ashby	Administrative Officer

Tobacco

H.H. Cheng, BSc, MSc, PhD	Entomology
W.A. Court, BSc, MSc, PhD	Chemistry
J.M. Elliot, BSA, MSA	Soil science
S.K. Gayed, BSc, MSc, PhD	Plant pathology
R.S. Pandeya,[1] BSc, MSc, PhD	Genetics and plant breeding
N. Rosa, BSc, MSc, PhD	Plant physiology
E.K. Walker, BSA, MS	Plant science
B.F. Zilkey, BSA, MSc, PhD	Plant physiology

New Crops

R.C. Roy, BSc(Agr), MSc	Agronomy

DELHI ENGINEERING RESEARCH GROUP[2]

D.A. Stier, BSc	Engineer

EXTENSION SERVICES[3]

N.W. Sheidow, BSc	Tobacco
M.C. Watson, BSA	Tobacco

AGRICULTURAL ENERGY CENTRE[3]

M.J. Columbus, BSc(Agr)	Energy Specialist

Departure

M. Skrypuch, BA(Eng), MLS	Librarian

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[1]On work transfer to Ottawa Research Station from September 1984 to August 1985.
[2]Provided by the Ontario Flue-Cured Tobacco Growers' Marketing Board and the Canadian Tobacco Manufacturers' Council.
[3]Provided by Ontario Ministry of Agriculture and Food.

INTRODUCTION

The Delhi Research Station conducts a multidisciplinary research program in support of the flue-cured tobacco industry in Ontario, Quebec, and the Atlantic Provinces. Basic research in genetics, chemistry, biochemistry, and physiology is conducted in support of mission-oriented research. Engineering research on energy utilization and mechanization is conducted by the Delhi Engineering Research Group (DERG), which is jointly funded by the Ontario Flue-Cured Tobacco Growers' Marketing Board and the Canadian Tobacco Manufacturers' Council. A new crops program is currently directed toward alternative or rotational crops for the sandy soils of the tobacco area.

Reprints of research publications and copies of this report are available from the Research Station, Research Branch, Agriculture Canada, P.O. Box 186, Delhi, Ont. N4B 2W9.

P.W. Johnson
Director

TOBACCO PRODUCTION

Germination and postgermination growth

Germination of tobacco seed in 10^{-4} *M* ethrel suppressed ion leakage into water, but no significant effects were observed at 10^{-7}–10^{-5} *M*. Fresh weight of seedlings at 33 days after start of germination was significantly lower for 10^{-6} *M* and 10^{-7} *M* ethrel. Abscisic acid concentrations of 10^{-6} to 10^{-3} *M* had no effect upon ion leakage into water. Germination was significantly decreased at 7×10^{-5} *M*. Postgermination growth was not significantly affected.

Seedling culture

Among three successive pullings at 5-day intervals from muck seedbeds, a reduction in shoot-to-root ratio (green-weight basis) was associated with improved field survival. Crop returns, however, decreased with the later transplanting.

A seedbed population of 1240 ± 50 plants per square metre in muck seedbeds produced seedlings that gave higher crop returns than seedlings produced in populations that were either less or more dense.

Seedling hardiness studies showed that the practices of seedbed forking and plant clipping or combination treatments thereof produced plants with superior characteristics that produced higher crop returns than plants hardened by water withdrawal only.

Topping, spacing, and sand-leaf removal

The yield of Delgold increased when plants were topped at 19 leaves rather than at 16 leaves. Removal of sand leaves prior to harvest resulted in lower yields at both topping heights. Price decreased with increasing topping height, but had no apparent correlation with removal or harvest of sand leaves. Plants topped at 19 leaves with sand leaves removed gave higher yields than plants topped at 16 leaves with sand leaves harvested when spaced at 61 cm × 107 cm and 71 cm × 107 cm, but gave lower yields when spaced at 51 cm × 107 cm.

Axillary bud growth inhibition

Fatty alcohols as sucker control chemicals provided excellent control of axillary buds when applied to tobacco plants at apical bud elongation and shortly thereafter. Experimental results showed that a single application provided more than 95% control of axillary bud growth, whereas two applications, the second applied 6–7 days after the initial coverage, did not significantly increase axillary bud inhibition. Commercially, however, unevenness of crop development necessitated the use of two, and in some instances three, applications.

Harvesting

Green-leaf yield of randomly oriented, mechanically harvested tobacco was 7.9% less than that of hand-harvested tobacco because of leaf loss in the harvesting operation. This represented a cured leaf loss of 249 kg/ha. The randomly oriented, mechanically harvested tobacco is cured in bulk kilns compared with bulk racks or lath curing for hand-harvested tobacco, and there was a further loss in curing for the mechanically harvested tobacco of 319 kg/ha to make a total loss of 568 kg/ha compared with hand-harvested tobacco.

Curing

Polyurethane foam and styrofoam sheets in downdraft kilns were effective for conserving fuel when applied to roof and gable ends, walls, or burner ducts. Polyurethane was somewhat more effective than styrofoam sheets in the roof and gable end areas.

Storage

Mold development in cured leaves during a 6-mo storage period varied with type of wrapping (paper or plastic), initial moisture content (18.5, 20.0, or 21.0%), and relative humidity (RH) of the storage environment (79, 60, or 48%). Mold development was minimal at an initial moisture content of 18.5% and storage environment of 60% RH, regardless of type of wrapping. At the storage RH level of 79%, plastic prevented uptake of sufficient additional moisture to cause mold, but paper-wrapped tobacco developed substantial mold.

GENETICS AND PLANT BREEDING

In collaboration with Dr. Keller of Ottawa Research Station, somatic hybrids were produced by fusing protoplasts derived from a cell suspension of chlorophyll-deficient *Nicotiana rustica* L. and an albino mutant of *N. tabacum* L. strain WS to combine nicotine-controlling genetic factors. Eleven somatic hybrids were evaluated for leaf nicotine, and three selected with the highest nic otine content were backcrossed to a commercial tobacco cultivar, Delgold. Three dosages of backcross were required to restore normal tobacco phenotype and gametic fertility. A total of 99 individuals were selected, based on their nicotine content. There was a 5- to 8-fold increase in nicotine compared with original donor parents, and values ranged from 0.9 to 3.9% as opposed to 0.54% for *N. rustica* and 0.21% for *N. tabacum* donor parents. Forty-one of the 99 selections were also screened for blue mold tolerance. Eight immune, 19 resistant, and 8 tolerant plants were isolated. Also, 16 progeny lines exhibited resistance to black root rot contributed by the *N. rustica* parent. These lines are the first examples of the practical utilization of biotechnology in plant breeding.

CHEMISTRY

Chlorogenic acid, its isomers (4- and 5-*O*-caffeoylquinic acid), rutin, kaempferol-3-rhamnoglucoside, scopoletin, and scopolin in the leaves of flue-cured tobacco were determined in samples collected at intervals from early in July through harvest. Quantitative differences were found among the four cultivars studied, but the changes during growth were similar for each cultivar and for each of the four years studied. Chlorogenic acid and scopolin increased with plant growth in each stalk position examined. Rutin, 5-*O*-caffeoylquinic acid, and kaempferol-3-rhamnoglucoside did not change appreciably, although there was a tendency toward lower levels with the later sampling dates. 4-*O*-Caffeoylquinic acid progressively declined throughout the study in the leaves of each stalk position. Scopoletin was below detectible levels (0.01 mg/g) in most of the early sampling periods but was present in mature leaves late in the sampling period.

TOBACCO PROTECTION

Entomology

Monitoring studies. Spring hatching rate of darksided cutworm eggs has been monitored at the Delhi Research Station for 17 yr. Results showed that the earliest egg hatch over the 17 yr began on 8 March 1983 and the latest egg hatch began on 14 April 1972. In general, over 90% of the eggs had hatched by mid April, and the optimum time for cover crop treatment was after 20 April each year.

Chemical control. Evaluation of six insecticides (acephate, cyfluthrin, cypermethrin, deltamethrin, flucythrinate, and permethrin) and a herbicide (diphenamid) applied sequentially or in tank-mixed combinations on tobacco seedlings after transplanting for determining their effects on the darksided cutworm, on weeds, and on the yield and quality of flue-cured tobacco revealed that all insecticides tested were compatible with diphenamid. No phytotoxicity was observed with any of the treatments. The performance of sequential applications of diphenamid and insecticides, or of insecticide-diphenamid combinations, was consistent and had similar degrees of affectiveness over the 4 yr. Treatments had no effect on the yield, grade index, reducing sugars, and total alkaloids in flue-cured tobacco, indicating that these combinations had no deleterious effect on tobacco quality. The cost of cutworm control by using this method of application was reduced by over 50%.

Plant pathology

Blue mold. Blue mold was not reported in Canada in 1984. No viable oospores of *Peronospora tabacina* were recorded in tobacco soil. Metalaxyl applied in planting water followed by a layby treatment provided effective protection and had no effect on smoke quality of the leaf. Six sprays of chlorothalonil increased tobacco yield.

Sprays of oxadixyl–chlorothalonil mixtures had no undesirable effect on yield and quality of tobacco, and growth chamber studies indicated

that oxadixyl is as effective as metalaxyl in protecting tobacco from *P. tabacina*. Tobacco leaf wetness was monitored, and dew was the main source throughout the growing season.

Black root rot. Application of imazalil in planting water reduced the incidence of black root rot caused by *Thielaviopsis basicola* but was phytotoxic. The soil fumigant SN 578 was as effective as Telone C-17 in controlling the disease, whereas SN 556 was considerably less effective.

Damping-off. In laboratory tests, benomyl was much more suppressive to *Rhizoctonia solani* than either glycophene or benodanil.

Pole rot. Three thermophilic fungi were isolated from cured tobacco leaves infected with rot. These were *Aspergillus flavus* and *A. niger* with an optimum growth temperature ranging from 30 to 35°C; the third was *A. fumigatus* ranging from 35 to 40°C.

Weed control

Various herbicide treatments were evaluated for their effect on flue-cured tobacco grade index, yield, return index, lamina total alkaloid, and reducing sugar content. Recommended herbicides (diphenamid and pebulate), a promising experiment herbicide (napropamide), annual grass control chemicals (sethoxydim, fluazifop-butyl, and CGA 82725), and a possible nut sedge control chemical (MBR 20457) produced no significant difference in agronomic and chemical results from the untreated check. No phytoxicity was observed with any of the chemicals tested.

NEW CROPS

Two hundred hectares of peanuts were grown in Ontario and produced wide-ranging (1200–3400 kg/ha) yields and grades (16–67% sound, mature kernels).

Agriculture engineering research and development contract funding resulted in the production of a one-row commercial once-over harvester. Area producers who used the harvester were quite pleased. Work on rotating disc cleaners produced promising experimental results. Curing experiments on peanuts indicated that if air temperatures exceed 30°C, then sour off-flavors are produced. An increase in the percentage splits, and a decrease in germination also occurs.

Preliminary evaluation of F6 peanut lines from the University of Guelph indicates a potential increase in yield of 10–20% over the newly released cultivar OAC Garroy.

Phoma arachidicola, which causes web blotch, was isolated and symptoms of the disease were reproduced by artificial inoculation. Two sprays of glycophene on 28 June and 26 July at a total rate of 2.5 kg/ha reduced leaf spots on peanuts by 45% without inducing a yield increase. Leaf wetness of peanuts was monitored during the growing season, and dew was found to be the main source of wetness.

Winter canola cultivar trials produced an average yield of 2800 kg/ha. Research indicates a planting date of 25–30 August, and an application of 40–50 kg/ha of nitrogen is required to ensure adequate winter survival.

The colored bean cultivar trial produced average (1690 kg/ha) yields 12% lower than those of 1983, primarily because of summer drought stress. Flour chick-peas produced yields of 1200–1500 kg/ha.

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Research Station, Harrow, Ontario

PROFESSIONAL STAFF

C.F. Marks, BSc(Agr), MSA, PhD	Director
P.B. Marriage, BSc, PhD	Assistant Director
L.P. Ryan	Administrative Officer
E. Champagne,[1] MA, MLS	Librarian

Crop Science

R.I. Buzzell, BSc, PhD	Head of Section; Soybean breeding
B.R. Buttery, BSc, PhD	Soybean physiology
V.A. Dirks, BSA, MSc, PhD	Statistics
S.J. Park, BSA, MS, PhD	Field bean breeding
A.H. Teich, BA, BSA, MSc, PhD	Winter wheat breeding
T.W. Welacky, BSc, BSc(Agr)	Burley tobacco

Entomology

R.P. Jaques, BSA, MSA, PhD	Head of Section; Insect pathology
G.J.R. Judd,[2] BSA, MPM	Vegetable insects
R.J. McClanahan, BA, MSc, PhD	Greenhouse and field vegetable insects
D.T.W. Quiring,[3] BSc, PhD	Field crop insects
B.C. Smith, BA	Field crop insects

Soil Science

W.I. Findlay, BSc, MSc, PhD	Head of Section; Soil fertility
T.J. Jewett, BSc	Greenhouse energy engineering
J.A. Stone, BS, MS, PhD	Soil physics
C.S. Tan, BSc, MSc, PhD	Soil moisture and agrometeorology

Horticultural Science

R.E.C. Layne, BSc, MS, PhD	Head of Section; Tree fruit breeding
R.W. Garton, BSc(Agr)	Vegetable cultivar evaluation and management
F. Kappel,[4] BSc(Agr), MSc	Orchard management
A. Liptay, BSA, MSc, PhD	Vegetable management
R. Michelutti, MSc	Viticulture
A.P. Papadopoulos, MSc(Agr), MSc(Hort)	Greenhouse management
V.W. Poysa,[5] BSc(Agr), PhD	Vegetable breeding

Plant Pathology

W.R. Jarvis, BSc, PhD, DIC	Head of Section; Vegetable diseases
T.R. Anderson, BSA, MSc, PhD	Soybean and corn diseases
W.G. Bonn, BSc, MS, PhD	Bacterial diseases of fruit
B.N. Dhanvantari, BSc, MSc, PhD	Bacterial diseases of vegetables
L.F. Gates, BA, PhD	Virology and vegetable diseases
J.A. Traquair, BSc, PhD	Tree fruit diseases
J.C. Tu, BSc, MSc, PhD	White bean diseases

Weed Science and Chemistry

A.S. Hamill, BSc, MSc, PhD	Head of Section; Weed science
J.D. Gaynor, BSc, MSc, PhD	Environmental chemistry
P.B. Marriage, BSc, PhD	Weed physiology
D.R. Phillips,[6] BSc, MSc, PhD	Weed physiology
S.E. Weaver, BA, PhD	Weed ecology

Departure

W.H. Foott, BSA, MSA, PhD Retired June 1984	Head of Section; Field crop insects

EXTENSION SERVICES[7]

J.C. Fisher, BSA	Greenhouse and fresh market vegetables
L.A. Huffman, BSc(Agr)	Fruit crops and asparagus

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[1]Seconded from Libraries Division, Finance and Administration Branch.
[2]On educational leave, Simon Fraser University, Burnaby, B.C., September 1983–.
[3]Joined staff 22 October 1984.
[4]Joined staff 22 May 1984.
[5]Joined staff 16 April 1984.
[6]Seconded to Canadian International Development Agency (CIDA) Barani (Rainfed) Agricultural Research and Development Project, Pakistan, 1 May 1983–.
[7]Provided by Ontario Ministry of Agriculture and Food.

INTRODUCTION

The research station at Harrow serves southwestern Ontario, where favorable soils and climatic conditions permit an intensive and diversified agriculture. The station has 34 researchers involved in interdisciplinary research in eight commodity-oriented programs designed to improve yield, quality, and efficiency of crop production. Crops under study include field and greenhouse vegetables, stone fruits, pome fruits, corn, soybeans, field beans, winter wheat, and burley tobacco. Crop improvements are achieved by the breeding of new varieties with superior characteristics and the development of improved crop, pest, and soil management practices.

Significant changes during 1984 are the addition to the staff of Mr. R. Michelutti, viticulturist; Dr. V.W. Poysa, vegetable breeder; Dr. D.T.W. Quiring, field crop entomologist; and the retirement of Dr. W.H. Foott, head of section, field crop entomologist.

The report provides brief summaries of results obtained in 1984. Further information can be obtained by writing to the Research Station, Research Branch, Agriculture Canada, Harrow, Ont. N0R 1G0.

C.F. Marks
Director

FIELD CROPS

Corn

Drainage coefficients and the contribution to streamflow of a Brookston clay soil. A procedure was developed to digitize and analyze tile flow data contained on strip charts, establishing a data base of tile flow parameters for the Woodslee experimental plots on Brookston clay soil spanning 22 years, from 1961 to 1982.

Tile flow parameters on a monthly, seasonal, and annual basis were grouped to describe three periods: a preparation and planting season (PPS), a growing season (GS), and a dormant season (DS).

The PPS, consisting of the months of March, April, and May, contained 44% of the tile flow events. The events in this season had a mean volume of 43 m^3, a mean duration of 144 h, a mean time to peak of 37 h, and a mean peak flow of 0.19 L/s.

The GS, consisting of the months of June–October, contained 22% of the total events. Tile flow in this period was characterized by a mean volume of 20 m^3—the volume is defined as the total amount of tile flow for the experimental plot area (929.6 m^2)—a mean duration of 68 h, a mean time to peak of 12 h, and a mean peak flow of 0.20 L/s. Peak flows in this season were higher than the other seasons, particularly for August and September, which exhibited mean peak flows of 0.37 and 0.25 L/s, respectively.

The DS, consisting of the months November–February, exhibited tile flow events similar to PPS, but fewer in number, accounting for 34% of the total number of events. The characteristics of this period were a mean volume of 37.2 m^3, a mean duration of 147 h, a mean time to peak of 35 h, and a mean peak flow of 0.16 L/s.

Flow volumes in August and September represented a higher percentage of the rainfall than the remaining months of the GS. This was accounted for by the large cracks formed in the clay soil, allowing water to flow interpedally instead of intrapedally. The cracks are formed during periods of high evapotranspiration and large soil water deficits.

Using seasonal probability plots of 12-, 24-, 36-, and 48-h equivalent depths, a methodology for the selection of a drainage design coefficient was established. The estimated coefficients were lower or comparable to the coefficients in the *Ontario Drainage Guide*. The advantages of the proposed methodology include the economic benefit of smaller drainage coefficients, knowledge of the risk associated with any drainage coefficient, and flexibility in allowing for seasonal variations, crop requirements, and characteristics of individual situations.

Herbicide application. Uniformity of application of herbicides is essential for effective and efficient use of these compounds. Basic elements of the spraying system, namely herbicide distribution to nozzles, nozzle tip uniformity, and consistency of spray patterns, were examined for their contribution to variability in herbicide spraying. Use of a refrigeration manifold with independent lines of equal length to each nozzle gave optimum herbicide distribution. Volume delivery between individual spray tips within a type (stainless steel, ceramic, plastic, nylon) was most uniform for the molded nylon tip. Accept-

ably consistent spray patterns were obtained on an average basis when spray tips within a type were compared using a collection apparatus. However, based on the highest and lowest amounts obtained at each collection position, large variations in droplet deposition occur across the nozzle spray width. These differences are accentuated by variation in the rate of total volume delivery among tips of a type. The unique spray patterns established by the average readings for each type indicated that careful attention must be paid to the degree of adjacent nozzle overlap to ensure uniform delivery across a bank of spray tips.

Soybeans

Breeding. Tofu was prepared from small samples (150 g) of soybean seed. Varieties differed in soaking time required to prepare the soybeans. Seed drying of high-moisture soybeans at harvest at 35 or 52°C reduced soaking time compared with air-drying of the seed, but location of seed production did not have an effect. Significant variety and location effects on the yield of tofu (volume and weight) were observed. Seed drying at 35 or 52°C did not affect tofu yield compared to air-dried seed.

Data for protein and oil content and yield were analyzed for 17 varieties grown over 3 yr at five locations in southwestern Ontario. There were significant differences in variety, location, and year for each of the three traits. Year effects were greater than location and variety effects for protein and oil content, whereas location effect was greatest for yield. Varieties were consistent relative to each other for protein and oil content over locations and over years, whereas yields of varieties ranked differently with locations and with years.

Phytophthora root rot. A 6-yr experiment to determine the effect of continuous use of soybean genotypes on populations of phytophthora root rot was completed. Continuous planting of soybean cultivars susceptible and tolerant of root rot resulted in equal spore concentrations of *Phytophthora megasperma* f. *glycine* (Pmg) in soil. Spore concentrations were lowest in plots planted continuously with a resistant cultivar.

Quackgrass control. The leaf extension of basal stem segments of quackgrass was measured following treatment with glyphosate plus additives to provide an early assessment of the relative effectiveness of treatments. Samples were taken 72 h after treatment and maintained with the lower cut ends in wet quartz sand for 24 h before measurement of leaf extension from the original top cut of the severed basal stem sheath. The presence of surfactant in the spray treatment appeared to enhance movement of glyphosate into the basal stem portion of quackgrass, as assessed by leaf regrowth inhibition. Ammonium sulfate as an additive did not have this effect, and its action on improving glyphosate activity likely has another basis.

Root development of eight indeterminate soybean cultivars under poorly drained soil conditions. The effect of poorly drained, nonflooded conditions on the early root growth of the soybean cultivars Amcor, Beeson 80, Corsoy, Hawkeye 63, Harosoy 63, Kentland, Premier, and Wayne, was evaluated. The drainage treatments were imposed by maintaining 0.0–0.002 m or 0.002–0.0028 m aggregate fractions of Brookston clay loam (clayey, mixed, mesic, Typic Haplaquoll) at <0.02 MPa suction. Accordingly, the finer fraction was wetter. Plants were grown until 21 days after emergence in acrylic tubes 0.0762 m in diameter and 0.92 m long that were immersed in baths maintained at a constant temperature of 23°C and located in a controlled-environment room. Daytime (16 h) ambient temperatures were maintained at 27°C and night temperatures at 20°C.

Taproot and lateral root extension was reduced in the less well drained soil, but the response varied between cultivars. Premier and Harosoy 63 exhibited the largest and Corsoy the smallest reduction in root extension. The number of upper lateral roots was not significantly affected by drainage. The top-to-root ratio was higher for the poorly drained soil, because of a greater reduction in root than in shoot weight. Soybean cultivars appear to differ in their ability to withstand poor soil drainage during the vegetative growth stage.

Seed mold. Cultivars with resistance and tolerance for seed mold have been studied to detect mechanisms of tolerance. Infection of tolerant pods is delayed approximately 1 wk under field conditions. Infection of tolerant seed occurs at a slower rate than susceptible seed. Additional studies are examining the biochemical and physiological basis of tolerance to seed mold.

Weed competition. Jimsonweed is increasing as a problem in soybeans in southern Ontario. It is a weed of tropical origin that has spread into Canada from the United States and may cause severe crop losses if not controlled. An examination of a number of populations collected from southern Ontario through Elgin County, Ont., revealed that the more northern plants have adapted to the shorter growing season. These plants have a shorter, more compact stature, larger seeds, and flower earlier than more south-

ern plants. Northern populations also have a great deal of genetic variability, and jimsonweed is likely to continue to expand its range northward, particularly in soybeans. Dense infestations of jimsonweed in Essex County, Ont., caused soybean yield losses of up to 49% compared with weed-free plots. Delayed planting of soybeans reduced the density and growth of jimsonweed and resulted in a slightly lower percentage of yield losses. Narrow rows (18 cm) and higher crop populations also reduced the density of jimsonweed. However, surviving weeds grew larger, so that the percentage of yield losses did not differ from those in wider rows (60 cm) and lower crop populations. Threshold levels for jimsonweed at which soybean yield losses could be detected varied from 0.3 plants/m^2 to 2.5 plants/m^2.

Weed control. The use of cultivation or close row spacing to enhance chemical weed control and improve soybean yields has proved to be very dependent upon time of planting, chemical treatment, rates of chemicals, and abundance of rainfall during the growing season. Late planting (mid June) and ample rainfall resulted in no advantage from cultivation or close row spacing. Mid-May or June planting with alachlor + linuron at 2.5 + 1.0 kg/ha followed by a dry summer resulted in increased yields with close row planting but not with cultivation, unless the herbicide rates were reduced by one-quarter, and then yields were increased by either cultivation or close row planting. Soybean yields where metribuzin at 1.0 kg/ha was used under the same conditions were not improved by either narrow rows or cultivation.

Weed control ratings in the dry summers were improved by either cultivation or narrow-row planting for both chemicals. Late planting plus ample rainfall during the summer permitted good soybean growth and effective chemical control, such that the two management techniques were unnecessary. For very little additional cost, the management option of cultivation may not always improve yields but will prevent further weed infestation and lessen future weed problems.

White mold. The tolerance of Ex Rico-23 was related to the pattern of movement of oxalic acid, a phytotoxic secretion of the white mold fungus, in leaf tissue. Feeding oxalic acid to excised leaves resulted in more severe brown rot symptoms on the leaves of the susceptible cultivars Kentwood and Seafarer than on those of Ex Rico-23. When ^{14}C–oxalic acid was supplied, radioactivity in the interveinal tissue of Kentwood was approximately three times higher than that of Ex Rico-23. Radioactivity in Ex Rico-23 was confined to major veins, but in Seafarer and Kentwood radioactivity was dispersed throughout the leaf tissue.

Burley tobacco

Variety testing. Results from 8 yr of variety evaluation at the station, along with 3 yr of testing at five farm locations, indicate that none of the 28 varieties tested were superior in yield or quality to the standard F_1 variety Burley 21 × Kentucky 10 currently being grown. Burley 21 × Kentucky 14 and R7-11 were similar in yield and quality to the standard variety.

Disease evaluations for tolerance of black root rot (*Thielaviopsis basicola*) demonstrated that the standard variety was moderately tolerant and that some varieties were superior in tolerance. Weather fleck evaluations indicated that of 14 varieties tested, the standard variety had an average level of tolerance, with no severe damage to leaves during above-average concentrations of ozone in the field. Agronomic and morphological characteristics of the 28 varieties did not vary greatly, because the varieties were closely related in the light type burley tobacco group. K.21 × 10, which was licensed in Canada in 1976, has plant growth characteristics suited to southwestern Ontario's climate, length of growing season, and soils.

Field beans

Breeding. Eighty-two introductions were evaluated in the field for resistance to common bacterial blight, caused by *Xanthomonas phaseoli*. Resistant lines include the following introductions: five *Phaseolus vulgaris* (L915, PI 207.207, Cornell XP-2 and XP-7, and MITA-8), four *P. coccineus* (PI 176.675, PI 181.790, PI 247.303, and PI 176.695), and six *P. acutifolius* (L-246, PI 319.443, PI 321.638, G40034, G40016, and L-Small white).

Interspecific hybridization between *P. vulgaris* × *P. acutifolius* was initiated because many tepary beans are highly resistant or immune to bacterial blight. From 13 *P. vulgaris* cultivars and 5 tepary bean introductions (as pollen parents), 340 embryos from 106 partly developed pods (up to about 21 days) were cultured on either Gamborg's B5 or Murashige-Skoog's medium.

Four plants from a cross between the cultivars Sacramento Light Red Kidney × Tepary Buff produced one pod each with one or two seeds, and F_2 plants of these hybrids were vigorous and set pods.

Interspecific F_1 hybrids between the white bean cultivar OAC Seaforth and the scarlet runner bean PI 165.421, reported as being highly tolerant of common bacterial blight, were highly abortive.

Therefore, the hybrids were crossed with several white bean cultivars to produce ample amounts of seed for breeding and genetic study. Reaction to blight and a few agronomic characteristics such as pod set, blossom date, and growth habit were observed in F_2 plants and F_3 rows in the field. Frequency distributions and means of F_2 and F_3 populations indicated quantitative inheritance of leaf and pod blight resistance in all four crosses examined. Regression of F_3 progeny on F_2 plants ranged from 3.2 to 72.6%, depending on crosses. There was no consistent association between resistance to leaf and pod blight. Late maturing plants tended to be more resistant to both leaf and pod blight, and poor pod set was associated with resistance to leaf blight.

Pink pod rot. Trichothecium roseum was identified as the cause of pod rot disease and pink discoloration of the seed coat of white beans. The fungus was sensitive to captan.

Screening for root-rot resistance. Compacting the soil of a root-rot nursery to a bulk density of 1.31 g/cm^3 before seeding significantly increased accuracy in screening segregating progeny of white beans for root-rot resistance.

Seed discoloration. In Ontario, gray and pinkish brown discoloration make up the major portion (91%) of bean discoloration, of which 80% is gray and 20% is pinkish brown. Brown to chocolate brown discoloration is caused by *Rhizoctonia solani*, *Actinomyces* spp., and other miscellaneous fungi. The pinkish yellow discoloration, caused by *Trichothecium roseum*, was noted in a few seeds from Ontario seed lots.

Wheat

Breeding. H 1-11-3, a soft white winter wheat line, has been recommended by the Ontario Cereals Crop Committee for licensing as the cultivar Harus. Among its strengths are yield that exceeds all licensed cultivars produced in Ontario; resistance to lodging, powdery mildew, and wheat spindle streak mosaic virus; low incidence of preharvest sprouting; low concentrations of α amalyase; and baking quality superior to Fredrick.

Fusarium head blight. Wheat planted after corn has much more *Fusarium* head blight and grain vomitoxin concentration than wheat planted after soybeans or small grains. A survey of 80 fields in three counties demonstrated in 1983, and confirmed in 1984, that the frequency of head blight and concentration of vomitoxin in the grain were 11 times greater where wheat followed corn.

Vomitoxin concentration in the grain began to decline 2 or 3 wk before grain maturity and continued to decline until grain moisture reached about 20%. The rate of decline appeared to vary with cultivar, location, and year.

Management. In the 1st yr of a study of four cultivars and five nitrogen levels at six locations covering the winter wheat area of Ontario, cultivars responded similarly to levels of nitrogen fertilizer, thereby supporting present nitrogen recommendations, which are uniform with respect to cultivars.

HORTICULTURAL CROPS

Field vegetables

Crucifer crops

Pest management. Studies toward development of an integrated pest management system for cabbage indicated that density of populations of the cabbage looper and cabbageworm was superior to foliar damage of the crop as a basis for decisions on application of chemical and microbial insecticides, especially applications to the late-season crop. It is noteworthy that applications based on action thresholds of less than 0.5 larvae per plant maintained crop damage at acceptable levels in field plots, but monitoring of fields suggested that growers used a much lower threshold.

Green peas

Cultivar tolerance of root rot. Of 178 cultivars of peas evaluated in a field heavily infested with root rot fungi, the majority were susceptible, 21 were tolerant, and 10 were highly tolerant. The highly tolerant cultivars are Melody, Perfection, W.R. X9500-1-1, 7801-10-3, Minn. 108, 80-717, SN5, Early Perfection, 777-15B, and Green Giant 531.

Etiology of root rot. Of 590 isolations from diseased peas in southwestern Ontario, there were *Fusarium solani* (356), *F. oxysporum* (119), *Aphanomyces* sp. (58), *Pythium* sp. (48), and *Rhizoctonia* and *Thielaviopsis* (6).

Aphanomyces euteiches was isolated in southwestern Ontario for the first time.

Lettuce

Bottom rot and lettuce drop. Symptoms in several fields in the Harrow area were caused by *Sclerotinia minor* (a new record), *S. sclerotiorum*, and *Botrytis cinerea*, the last often in conjunction with one of the *Sclerotinia* species.

Peppers

Pest management. Cultivars of pepper, early and late planting, and methods for control of weeds and insects were compared in a field plot test. The yield pattern differed with the planting time, but over six pickings the total yields of early- and late-planted peppers were not significantly different. Combining both planting dates, the yield of Lady Bell was higher than the yield of Hybelle and Staddon's Select. The yield from plots sprayed with insecticides was 36% higher than yields from unsprayed plots, suggesting that protection against the pepper maggot and European corn borer enhanced yield in addition to reducing damage by the pests. The method of weed control did not influence yield.

Varietal resistance to corn borer. Nine varieties of bell-type peppers exposed to natural populations of European corn borer varied significantly in the level of fruit infestation in nonsprayed field plots. Lady Bell was least damaged at 4.0%, Hybelle was 5.1%, and Yolo Wonder was 8.7%. Varietal rank was consistent with 1982 and 1983 results.

Potatoes

Insect control. As in 1983, aldicarb at one-half the recommended rate allowed a few Colorado potato beetle larvae to develop, but the yield of potatoes was not affected. Aminofuracarb and trimethacarb were inadequate as furrow treatments as was alphamethrin as a foliar spray, which killed only 73% of the potato beetle larvae. Laboratory studies indicated that PP231 and a chlorpyrifos–cypermethrin combination should provide excellent control of potato insects.

Squash

Control of watermelon mosaic virus. A field trial was set up to test mulches reported to provide leaf backgrounds less attractive to aphids than leaves against bare soil. White plastic mulch, sawdust, and straw were tested. A center plant in each plot of bush vegetable marrow was inoculated with watermelon mosaic to act as a virus source. Plots with mulches had fewer virus-infected plants in July and August than the controls; at the last count on 8 August, control plots contained 93% infected plants, white plastic-mulched plots 74%, sawdust-mulched plots 78%, and straw-mulched plots 43%.

Sweet corn

Resistance to the European corn borer. First-instar larvae from a corn borer colony collected in September 1983 had a threefold resistance to carbaryl compared with 1981 toxicity tests. The recommended sprays of carbaryl on 1984 mid-season sweet corn were inadequate, allowing 37% infested ears. Similarly, permethrin failed to provide the level of control that it had in the past. Carbofuran, cypermethrin, and several experimental insecticides gave good control in the same circumstances.

Varietal resistance to corn borer. Research over the last 7 yr has proved that certain sweet corn hybrids can be grown as an early crop without ear infestation by European corn borer, whereas 10–25% of ears of more susceptible hybrids may be infested. The earlier the cultivar develops silk, the more likely it is to be infested ($r = -.85$). For example, in 1984, if the 50% silk stage was reached after 14 July, 5% or less of the ears were infested. Genetic factors are present in certain hybrids so that they are consistently more or less resistant than expected. Such resistance was indicated by the low infestation of ears of 4 of 10 hybrids tested for the first time in 1984.

Tomatoes

Bacterial canker. In late June, bacterial canker appeared on southern transplants in a number of processing tomato fields from Essex to Norfolk counties. Among those severely affected were Canadian Canners 7104 and Heinz 722. While stem cankers, blisters, and scorching of leaf margins were generally seen, other symptoms typical of canker, namely, bird's-eye spot on fruit, and vascular and seed discoloration within, were absent. Severely affected fields had stunted plants with practically no harvestable yields, while in others, the yield was reduced up to 30%.

Preliminary studies showed systemic infection of symptomless seeds within symptomless fruits on cankered plants. When these seeds were extracted from pulp and fermented up to 48 h at room temperature (~23°C), there was evidence of disinfection without impairing germination.

Bacterial speck. Survival of *Pseudomonas syringae* pv. *tomato* as an epiphyte occurred during shipment of symptomless tomato transplants from Georgia to Ontario. Disease occurred on these transplants in the field.

Transplants inoculated in Georgia with 10^8 colony-forming units (cfu) per millilitre of *P. syringae* pv. *tomato* were assayed 1 h postinoculation, 24 h later in both Georgia and Ontario, after brief poststorage periods in Ontario, and finally after 7 days. Initial population levels of 10^5 cfu per leaf at 1 h declined to 10^4 cfu per leaf in Ontario and 10^2 cfu per leaf in Georgia, but then increased to 10^7 cfu per leaf in Ontario and 10^6 cfu per leaf in Georgia. Changes in epiphytic population were not influenced by cultivar or storage period.

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Consequently, until more effective control measures are developed, current control practices in Georgia using streptomycin and copper compounds should be adhered to rigorously, even during the apparent absence of bacterial speck.

Cost-effective greenhouse production of tomato transplants. In order to revive domestic tomato transplant production (approximately 300 000 000 are produced outdoors and imported from Georgia, USA, each year) the production system has to be made more cost-effective. A greater number of seedlings grown per unit area (e.g., 1 seedling per 10 cm^2) of bench space in the greenhouse would be a possible solution. However, at this density, seedlings are very spindly and not suitable for transplanting outdoors. Two methods of obtaining shorter, stalkier transplants were devised. The relative thickness of the stem could be increased either with an ethephon spray (300 ppm) at the 3- to 4-wk stage of growth or by an intermittent vibration of the seedlings with forced air. The air-vibration treatment was done by placing plastomer, multicelled flats containing tomato seedlings close to each other on a wire-mesh bench, covering the sides of the bench with plastic curtains, and forcing air from underneath the bench by a fan installed at the end of the bench in the curtain. The air from the fan was forced through 0.5-cm holes made at the corners of each of the cells in the tray. Thus, each seedling received similar vibration by air movement (twice each day for 1-h periods). The heights of the seedlings were reduced; the transplants were stalkier and withstood the transplanting procedure very well. Further work is being done to test the systems on a semicommercial scale.

Herbicide tolerance. Eighteen varieties of tomatoes were tested for their relative tolerance to the herbicide metolachlor. Metolachlor was applied in nutrient culture at a concentration of 2 ppm when the tomato seedlings were at the cotyledon stage. Leaf areas were measured at the first leaf stage. Over the treatment period, the only effects observed from metolachlor were slight stunting of plant development and isolated minor leaf curling. Most varieties showed a reasonable tolerance for metolachlor at this rate, and growth of treated plants ranged generally from 69 to 84% of the controls. Exceptions were FM 6203, which had a high degree of tolerance, and ST 61, which exhibited poor tolerance and a significant reduction in growth.

Irrigation and plant population effects on yield, fruit speck, and blossom-end rot. Two tomato cultivars, Heinz-2653 and Campbell-28, were grown on Fox loamy sand in the subhumid region of southern Ontario between 1979 and 1982. Irrigation increased the marketable yields of H-2653 in a dry year, 1982, but not in other years. Irrigation substantially increased marketable yields of C-28 in 1979 and 1982. Irrigation of tomatoes when the available soil moisture (ASM) level reached 50% was no more effective than irrigation when the ASM level in the soil was allowed to drop to 25%. Without irrigation, yield increased as plant population increased in normal and wet years, but not in a dry year. High plant populations increased yield in a dry year only under irrigated conditions. Blossom-end rot of the C-28 cultivar was markedly reduced by irrigation. Effects of irrigation or plant population treatments on the incidence of fruit speck did not appear to be significant.

Seed extraction. Duration of the fermentation period and temperature of the fermentation pulp were important factors in seed germination and seedling vigor. The upper limit for fermentation time was 25 h if temperature of the fermentation pulp was $\geq 30°C$. Beyond this limit, seed germination and seedling vigor were reduced. Neither seed germination nor seedling vigor was reduced if fermentation was extended to 48 h at 25°C or lower.

Starter fertilizer. Experiments were done to determine the effect of placing starter fertilizer in the furrow (1.5 g of 20-20-20 in 300 mL of water per metre of row) on the germination and growth of tomato seedlings. Starter fertilizer did not improve germination or emergence through the soil, but subsequent growth of the seedling was much more rapid if the seedlings had starter fertilizer in the furrow. In both a 3 May and a 14 May seeding, growth of seedlings for about the first 2-3 wk after emergence was maintained at about 130 g fresh weight (FW) per 100 heat units (base 10°C) if there was starter fertilizer in the furrow. Without starter fertilizer, growth in FW was only 90 g/100 heat units for the 3 May seeding and only 60 for the 14 May seeding. There appears to be a critical fertilizer–water relationship for optimum growth of emerged seedlings, especially in the early stages of growth in the field.

Weed control. Direct seeding of tomatoes has the potential of very great cost saving to the grower, both in time and labor. To date, the most serious impediment has been weed control. There are very few herbicides of which tomato seedlings are tolerant. Activated charcoal has shown potential for protecting the seedlings. Comparisons were made among the following: charcoal sprayed over the seed row, charcoal placed on vermiculite in the seed row, and no charcoal at all. Charcoal sprayed over the row protected the

tomato seedlings and the weeds from herbicide injury, but the tomato plants were unable to recover from competition from the weeds in the row. Charcoal placed in the seed row provided excellent protection to the seedling tomato and good to excellent weed control. Where no charcoal was used, the tomato seedlings were injured by most herbicide treatments in 1984; however, the seedlings recovered to produce yields much closer to those in which charcoal was placed in the seed row than when sprayed over the seed row. The chemical treatments that gave the highest yields were trifuluralin at 1.0 kg/ha, preplant incorporated, followed by metribuzin at 0.28 kg/ha over the row and 0.56 kg/ha on each side of the row, applied preemergence; or metolachlor plus metribuzin at 1.68 kg/ha plus 0.56 kg/ha applied preemergence.

Greenhouse vegetables

Cucumbers

Biological control of the whitefly. The entomofungus *Verticillium lecanii*, a pathogen of interest for control of the greenhouse whitefly and aphids on greenhouse crops, was quite effective against the whitefly in cage tests. The effectiveness of the fungus was quite variable against the whitefly on cucumbers in large-scale tests, apparently because of difficulty in maintaining a high relative humidity in large compartments of the greenhouse.

The parasite *Encarsia formosa* and the entomofungus *V. lecanii* appear to interact negatively when used at the same time for control of the whitefly under normal environmental conditions for production of a greenhouse cucumber. For example, after 34 days, the incidence of parasitism by *E. formosa* was 63% less and the number of the whitefly was 3.2 times greater in a greenhouse section in which the fungus and the parasite were introduced than in a section in which the parasite was used alone.

Powdery mildew and gummy stem blight. Excellent control of cucumber powdery mildew, *Sphaerotheca fuliginea*, was obtained by oxalixyl in combination with mancozeb and by imazalil, but iprodione exerted little control. All three treatments controlled gummy stem blight (*Didymella bryoniae*).

Solarization of greenhouse groundbed soil. The feasibility of pasteurizing greenhouse groundbed soil by the solarization technique was examined for a group of vegetable pathogens: *Botrytis cinerea*, *Pythium* sp., *Pyrenochaeta lycopersici*, *Phomopsis sclerotioides*, *Rhizoctonia solani*, and *Fusarium solani*. Fungal cultures on agar were buried at 10 or 20 cm in a sandy loam amended with peat, and the groundbed was covered by a twin layer of 100 μm clear polyethylene for 19 days during June 1984. Degree-hours to base 30°C were 342 at the surface, 400 at 10 cm, and 388 at 20 cm; to base 35°C they were 246, 249, and 175; and to base 40°C they were 184, 117, and 0, respectively. After 19 days, some cultures of *R. solani* had survived at 20 cm, and all cultures of *F. solani* had survived at 10 and 20 cm. All other cultures were killed.

Lettuce

Powdery mildew. A greenhouse crop of butterhead lettuce, cultivars Salinas, Ostinata, and Revel, grown under nutrient film technique in Aylmer, Ont., was found to be infected by *Erysiphe cichoracearum* as determined by conidial morphology. The perfect stage was not found. This is the first report of powdery mildew on lettuce in Canada.

Tomatoes

Gray mold stem rot. Stem rot, caused by *Botrytis cinerea* was effectively controlled by an aqueous paste of iprodione applied to incipient lesions and deleafing scars. Preliminary experiments also indicated that some isolates of *Trichoderma* spp. controlled the disease.

Residues of chlorothalonil. Three applications of Bravo 500 at 1.6 and 3.2 mL/L sprayed to incipient runoff did not result in chlorothalonil residues on fruit greater than 1.5 μg/g or 2.8 μg/g, respectively, at any time within 10 days of last application (the official tolerance level is 5 μg/g).

Chlorothalonil is a useful fungicide for controlling gray mold but in this trial the disease level was too low to obtain efficacy data. The trial was conducted in cooperation with the Ontario Pesticide Testing Laboratory.

Stem rot. The disease, caused by *Erwinia carotovora* ssp. *carotovora*, was characterized by an extensive slimy rot of the lower stem and disintegration of the pith, leaving the stem hollow. Substantial losses occurred on the cultivar CR-6 in three Essex County greenhouses in 1983. Infection appeared to have originated at basal leaf-removal wounds. The disease, generally seen on mature, bearing vines, was significantly more severe in rows under roof gutters, where dripping of water condensate occurred. In vitro tests also demonstrated that the cultivars Dumbito, Jumbo, and MR-13 were susceptible to the disease.

Stem and pith necrosis. Stem and pith necrosis of the tomato cultivars Dumbito, Jumbo, and Laura from greenhouses in Lincoln and Norfolk counties was caused by *Pseudomonas cichorii*.

The same organism was also isolated from butterhead lettuce showing butt rot, and from spray chrysanthemum plants with stem necrosis and leaf blight. The bacterial strains were blue-fluorescent on King's B agar, but were phenotypically variable, producing blue, green, or orange diffusible pigment. On mature vines of the cultivar CR-6, inoculation of *P. cichorii* strains produced systemic stem and leaf necrosis, followed by pith necrosis.

The Harrow peat bag system for greenhouse tomatoes. The cropping of greenhouse tomatoes in peat bags (each measuring 0.35 m × 1.05 m and containing 42 L of fertilized peat) has shown promise for energy conservation and efficient use of labor, and has been popular in the UK, where 25% of the greenhouse tomatoes are grown in peat bags. In 1981, a growing medium for peat bags was formulated and a suitable fertilization schedule was developed, thus providing a complete home-made peat bag system (named Harrow) for tomato cropping. In comparative trials over the last 3 yr with three popular greenhouse tomato cultivars, the production capacity of the Harrow peat bag system has been shown to be as good as that of conventional soil-based production methods and comparable to or better than that of other peat bag systems studied. Further experiments are being conducted with the objective of refining the nutrition and watering requirements of newly available cultivars of greenhouse tomatoes when grown in Harrow peat bags.

Tree fruits

Apricot

Breeding. The combination of a very severe winter (–28°C, 21 January) and a cold, wet, spring provided a unique opportunity to select for cold hardiness and ability to set a crop under adverse pollinating conditions. Seventeen new selections were made from 1978 crosses that possessed these traits combined with a number of important tree and fruit characteristics being sought in the breeding program. The new selections provided a 27-day ripening sequence from 13 July to 9 August. Harcot, Harlayne, and Harglow were the most prepotent of the seven parents tested in transmitting desirable traits to their offspring.

Grape

Diseases. The fungus *Aspergillus aculeatus*, which caused a bunch rot of grapes in 1983, was found to form sclerotia in culture. They were previously unknown in the species. The sclerotium is typical of the lateral strand type, with rind, cortex, and medulla. Cells of the cortex and medulla are interconnected by conspicuous pits. The bunch rot did not appear in 1984.

Peach

Breeding. An early-season, fresh-market peach cultivar was introduced, Harrow Diamond, formerly tested as HW 213. Harrow Diamond is an attractive, medium-sized, yellow-fleshed freestone peach that ripens with Earlired, about 28 July at Harrow. The fruit is well suited for the fresh market, including local sales and shipping. The tree appears to have moderate field tolerance to perennial canker, caused by *Leucostoma cincta* (Fr.) (Höhn) and *L. persoonii* (Wits.) Höhn. The foliage and fruit are resistant to bacterial spot, caused by *Xanthomonas campestris* pv. *pruni* (Smith) Young et al., and the flowers and fruit are resistant to brown rot, caused by *Monilinia fructicola* (Wint.) Honey. The fruit is also very resistant to split pits, preharvest drop, and flesh oxidation. Harrow Diamond is adapted to regions of southern Ontario where the Redhaven peach is successfully grown. It is intended as a replacement cultivar for Candor and Earlired, which are less hardy and more subject to split pits.

Integrated orchard management. The effects of irrigation and tree density on peach production (Harken–Siberian C) were investigated over 11 years.

Irrigation improved growth of peach trees, lowered levels of winter injury and perennial canker (*Leucostoma* spp.), and promoted tree survival. Annual and cumulative marketable yields were increased, especially in later years. Tree density did not affect perennial canker, winter injury, or tree survival. A reduction in tree spacing increased total growth per hectare and annual and cumulative marketable yields. Irrigation and density treatments usually did not interact and had an additive effect on growth and fruit production. The most productive management system (a combination of 50% available soil moisture and 536 trees per hectare) resulted in accumulated yields over 8 yr of 179 t/ha compared with only 74 t/ha for the check treatment (no irrigation and 255 trees per hectare).

Soil-water status in the rooting zone of irrigated and unirrigated peach trees. Available soil moisture (ASM) in the rooting zone of mature peach trees was determined with a neutron probe at incremental depths down to the water table between 1979 and 1982. The trees were either not irrigated or irrigated at a frequency necessary to prevent the ASM from falling below 25 or 50%. In the summer and fall of each year, nonirrigated plots had less ASM in the entire rooting depth

than irrigated ones. In dry and wet summers, respectively, nonirrigated plots had only 10 and 30% of the ASM in the top 120 cm, where most of the roots are located. By contrast, in irrigated plots (50% ASM) the ASM was more than 50% during the whole season both years. We reported earlier that lack of irrigation resulted in reduced peach tree growth, fruit size, and annual marketable yields. In addition, it resulted in increased susceptibility of nonirrigated trees to perennial canker infection and winter injury, which in turn resulted in significantly more tree losses than in irrigated plots. Soil moisture stress during summer and fall undoubtedly played a part in the above responses.

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Research Station, Ottawa, Ontario

PROFESSIONAL STAFF

T. Rajhathy, Ing Agr, MSc, D Agr Sci, FRSC	Director
J.G.R. Loiselle, BSc(Agr), MSc, PhD	Plant gene resources of Canada
R. Porteous	Head, Administration and resources
Vacant	Finance and general services
R. Running	Personnel services

Cereal Crops

V.D. Burrows, BSA, MSc, PhD	Head of Section; Oat breeding
V. Clark, BSc(Agr), MSc, PhD	Oat and barley pathology
J. Frégeau, BSc, MSc, PhD	Crop physiology
R.G. Fulcher, BSc, MSc, PhD	Morphogenetics and grain quality
M.J. Morrison,[1] BSc	Integrated pest management
K.M. Ho, BSc, MSc, PhD	Barley breeding
D.R. Sampson, BSc, AM, PhD	Wheat breeding
W.L. Seaman, BSc, PhD	Wheat pathology

Cytogenetics

G. Fedak, BSA, MSc, PhD	Head of Section; Cereal cytology
K.C. Armstrong, BSA, PhD	Brome cytology and chromosome banding
I.L. Craig, BS	Hordeum cytology

Entomology

D.G. Harcourt, BSA, PhD	Head of Section; Population dynamics
T.A. Gochnauer, BS, MS, PhD	Pathology of bees
J.C. Guppy, BSA, MS	Population dynamics
C.C. Loan, BA, MS, PhD	Population dynamics
F. Meloche,[2] BSc, MSc	Population dynamics

Forage Crops

R.I. Hamilton, BSc, MSA, PhD	Head of Section; Corn breeding
P.K. Basu, BSc, MSc, PhD	Plant disease
M.A. Faris, BSc, MSc, PhD	Legume breeding
A.R. McElroy, BSc, MSc, PhD	Grass breeding
H.D. Voldeng, BSA, MSc, PhD	Soybean breeding
F.S. Warren,[3] BSA, MSc, PhD	Agronomy

Genetic Engineering

W.A. Keller, BSA, PhD	Head of Section; Cell genetics
D. Brown, BSc, MSc, PhD	Developmental physiology
S. Gleddie,[4] BSc, MSc, PhD	Cell genetics
B.L.A. Miki, BSc, PhD	Molecular genetics
S.J. Molnar, BSc, MSc, PhD	Cell genetics

Ornamentals

A.T. Bolton, BSc, MSc, PhD	Head of Section; Pathology
S. Nelson, BSc, MSc, PhD	Nursery research
J.A. Simmonds, BSc, MSc, PhD	Physiology and floriculture
F. Svejda, PhD	Plant breeding

Experimental Farm, Kapuskasing, Ont.

J.G. Proulx, DVM	Superintendent; Crop and beef management

Experimental Farm, Thunder Bay, Ont.

J. Wilson	Superintendent; Crop management and evaluation

Departures

R. Boch, Dr Rer Nat Deceased June 1984	Physiology and behavior of bees
C. McCarthy Transferred February 1984	Finance and general services
B.E. Murray, BSA, MSc, PhD Retired January 1984	Haploidy—flax cytology
E.V. Parups, MSA, PhD Retired March 1984	Physiology and floriculture
T. Rajhathy, Ing Agr, MSc, D Agr Sci Retired December 1984	Director

VISITING SCIENTISTS

M. Dijak, BSc, MSc, PhD From September 1984 to September 1986	Developmental physiology
P.K. Gupta, BSc, MSc, PhD From May to August 1984	Cereal cytogenetics
L.A. Holbrook, BSc, MSc, PhD From May 1983 to May 1985	Molecular genetics
K. Klimaszewska, MSc, PhD From December 1981 to December 1985	Cell genetics
D.D. Lefebvre, BSc, MSc, PhD From August 1984 to August 1986	Cell genetics
E.G.M. Meijer, BSc, MSc, Dr Agr From April 1984 to April 1986	Cell genetics
D.H. Simmonds, BSc, MSc, PhD From April 1984 to April 1986	Cell genetics
D.L. Smith, BSc, MSc, PhD From September 1984 to August 1985	Forage legume and plow down
C.T. Ta, BSc, MSc, PhD From April 1984 to March 1985	Forage legume and N_2 fixation

Graduate Students

H.A. Burity, MSc	Forage legume and N_2 fixation
P. Charest, BSc, MSc	Molecular genetics
R. Langis, BSc (Hon)	Cereal winterhardiness
S. Miller, BSc (Hon)	Cereal quality
A. Plourde, BSA, MSc	Cereal cytogenetics
T. Reich, BSc, MSc	Molecular genetics
A. Sproule, BSc	Cell genetics
R. Vidoli, BSc, MSc	Molecular genetics

[1]Appointed March 1984; on educational leave.
[2]On educational leave.
[3]On a Canadian International Development Agency (CIDA) assignment to Tanzania from May 1984 to May 1986.
[4]On a transfer of work to Plant Breeding Institute, Cambridge, England, from December 1984 to December 1985.

INTRODUCTION

The Ottawa Research Station (ORS) is the major center for plant breeding in eastern and central Ontario. It also has substantial programs in biotechnology, integrated pest management, and ornamentals research. The central office for the Canadian Plant Gene Resources is part of the station, and a small unit is engaged in honey bee research. The management of the Central Experimental Farm, including numerous services, is also the station's responsibility.

The experimental farm at Kapuskasing conducts experiments in crop and silage production and beef cattle management for the Northern Claybelt, in collaboration with the Animal Research Centre (Ottawa). The experimental farm at Thunder Bay is engaged in field trials, crop production, and the testing of horticultural crops for northwestern Ontario.

Of the three new short-season soybean cultivars developed in 1984, one is adapted to Ontario and Manitoba, another to Ontario and the Maritimes, and the third is a food-type natto cultivar. In addition, six corn hybrids and an alfalfa cultivar with multiple disease resistance were supported for licensing. In cooperation with the Delhi Research Station, agronomic lines of tobacco hybrids, possessing blue mold resistance and high nicotine and low tar content, were produced by protoplast fusion. Eggplant and *Solanum sisymbriifolium* hybrids with nematode and *Verticillium* resistance were also produced using this new technology.

Dr. Harvey Voldeng, in recognition of his outstanding results as a soybean breeder, was named Man of the Year by the Canadian Seed Trade Association. Dr. Bea Murray, cytogeneticist, and Dr. Ed Parups, ornamentals physiologist, retired after 35 and 29 years, respectively, of distinguished service. The staff was much saddened by the untimely death of Dr. Rolf Boch, an eminent researcher of honey bee behavior and pheromones.

This report summarizes only some of the more important research results from the station in 1984. Further information can be obtained from the publications listed here. Reprints of the research publications and copies of this report are available on request from the Ottawa Research Station, Research Branch, Agriculture Canada, Ottawa, Ont. K1A 0C6.

Tibor Rajhathy
Director

CEREAL CROPS

Wheat

Breeding. Three ORS lines that excelled in the Ontario screening test in 1982–1983 continued to show promise in the Ontario Cooperative Test in 1983–1984. These three, 0-97-32-1, 0-97-40-1, and 0-99-6-1, have excellent straw strength and achieve our goal of combining higher test weight with lower grain protein. The first and third have good mildew resistance, the second and third have good leaf rust resistance, and the third has better sprouting resistance than the widely grown cultivar Fredrick.

Genetics. Eighty-one experimental spring wheat lines from crosses segregating for the *Rht-2* dwarfing gene were classified in the seedling stage for the presence of *Rht-2* by their lack of growth response to gibberellic acid (GA) treatment. When grown in replicated field trials, the GA-insensitive lines were an average of 23 cm shorter than their sensitive sibs. They also had lower test weight (kilograms per hectolitre) and 1000 kernel weight. This agrees with the observation that all Ontario soft white winter wheat cultivars that possess *Rht-2* have lower test and 1000 kernel weights.

Physiology. Resistance to preharvest sprouting of entries in the Ontario Winter Wheat Cooperative Test was evaluated using a rain-simulator for intact spikes and a germination protocol on threshed grains. The cultivar Fredrick again showed the lowest percentage of germination and Houser the highest value among the commercial cultivars. Fredrick kernels reached 20% moisture content 5–6 days earlier than Houser. Houser maintained its high rate of germination throughout maturation and dehydration, whereas Fredrick displayed a much lower rate as dehydration progressed.

Pathology. Winter survival of soft white winter wheat was excellent in most production areas. Serious losses from water and ice-encasement damage occurred on poorly drained soils in the southwest and on hard red winter wheat in northwestern Ontario. Damage from snow molds was light to moderate in areas with extended snow cover; several fungi were implicated, including a

form of *Typhula* not previously associated with snow mold damage. Wheat spindle streak mosaic was severe in experimental plots and was probably widespread in the field, although symptoms were often masked by the general yellowing of the crop during an extended cool wet spring. Powdery mildew (*Erysiphe graminis* DC. ex Mérat) and septoria leaf spots (*Septoria* spp.) were prevalent on the lower canopy in spring but did not progress following the onset of warm dry conditions. Considerable leaf rust (*Puccinia recondita* Rob. ex Desm.) and late season septoria glume blotch (*Septoria* spp.) occurred in some areas. As in 1983, fusarium head blight [*Gibberella zeae* (Schw.) Petch.] was very light and vomitoxin levels were not of concern. Root rots, including take-all [*Gaumannomyces graminis* (Sacc.) Arx & Olivier] and eye spot [*Pseudocercosporella herpotrichioides* (Fron) Dei.] are of increasing concern. Screening tests for resistance to leaf rust, powdery mildew, and loose smut [*Ustilago tritici* (Pers.) Rostr.] continued.

Barley

Breeding. Léger, a six-rowed feed barley licensed in 1982, represents a new level of excellence in spring barley in eastern Canada. It has consistently exhibited exceptionally high yield, good test weight, large kernel size, and strong straw. Sufficient quantities of certified seed will become available in 1985. A backcrossing program to incorporate a higher level of mildew resistance into Léger is nearing completion.

Four promising ORS entries were promoted to the Eastern Cooperative Six-Row Barley Test. The two-row barley breeding program continues to progress, and new lines will be evaluated in advanced trials in 1985.

Pathology. Net blotch [*Pyrenophora teres* (Died.) Drechsl.], spot blotch [*Cochliobolus sativus* (Ito and Kurib.) Drechsl. ex Dastur], and scald [*Rhynchosporium secalis* (Oud.) Davis] were prevalent diseases in Ontario in 1984. Leaf stripe (*Pyrenophora graminea* Ito & Kurib.) was found again in trace amounts in several seed stocks. Treatment of infected seed with maneb wettable powder (drill-box formulation) and four experimental systemic chemicals gave effective control of the disease. An intensive cereal management test using Massey barley showed that in 1984 the addition of ethephon growth retardant and propiconazole (Tilt) fungicide increased yields by 15% and 38%, respectively.

Oats

Breeding. Licensing trials have been completed for the naked oat line OA501-1, and a license will be sought in 1985. OA501-1 is superior to the check cultivar Terra in yield, hectolitre weight, seed size, seed protein content, straw yield, straw strength, and smut and crown rust resistance (slow ruster). Preliminary experiments at ORS and the Animal Research Centre revealed that naked oats performed well in poultry (boiler) and pig rations. Extensive trials are under way to determine if they can serve efficiently as the sole source of energy and protein for pigs. New semi-dwarf, naked-seeded dormoat and rust resistant oat strains have been developed and currently are being evaluated in advanced trials.

Physiology. A protocol to successfully induce secondary dormancy in dormoats was assessed. Induction was initiated within 2 days by incubation of moistened seeds in a humid atmosphere at 40°C. Maximum number of induced seeds was obtained between 4 and 7 days, depending on the dormoat strain. Induction was most effective on seeds freshly after-ripened; seeds 6 mo old were not induced by the treatment.

In a field, freshly havested seeds from two dormoats, OA 499 and OA 635-3, and one oat cultivar, Donald, were mixed with soil in plastic mesh bags and sown in the field in September for retrieval at various times in the fall and winter to assess the dormancy status of the ungerminated seeds, i.e., innate primary dormancy or naturally induced secondary dormancy. After 1 mo in soil, all the seeds from Donald germinated, whereas OA 635-3 had approximately 50% of its seeds induced into secondary dormancy; for OA 499, the percentage of ungerminated seeds corresponded to the seeds still in primary dormancy at planting.

Pathology. Diseases of oats were generally light, with crown rust (*Puccinia coronata* Cda.) being the most prevalent, particularly in eastern Ontario. Intensive management tests with Donald oats and with mixtures of Donald and Léger barley showed that extra N did little to increase yields. Chlormequat growth retardant and propiconazole fungicide applied to the foliage improved yields substantially. Unsprayed oat and barley mixtures showed little improvement over the pure components, and a 1:1 oat-to-barley ratio gave the poorest performance.

Grain quality and microchemistry.

Several fluorescein isothiocyanate-conjugated lectins permit identification and localization of specific carbohydrates by fluorescence microscopy. In collaboration with the Food Research Institute, experiments were undertaken to assess the distribution of glucosinolates in rapeseed. A new histochemical method for glucosinolate detection has been developed using *N*-2,6-tri-

chloro-*p*-benzoquinoneimine (TCQ) as the staining reagent. TCQ demonstrated improved selectivity for glucosinolates in thin-layer chromatographic systems, and the specificity was confirmed by gas liquid chromatography. When applied to tissue sections and treated with TCQ, cotyledonary protein bodies were stained intense yellow, which is indicative of glucosinolate residues in the protein bodies.

CYTOGENETICS

Cereal cytogenetics

Callus culture and plant regeneration from immature inflorescence was evaluated as a means of propagating sterile intergeneric hybrids and as a technique for inducing chromosome rearrangements. In this way a total of 10 intergeneric hybrids were regenerated. These included hybrids of *Hordeum* × *Secale* (4), *Triticum* × *Secale* (3), *Triticum* × *Hordeum* (2), and *Triticum* × *Agropyron* (1). In 7 of the 10 regenerants, the meiotic chromosome was unchanged from the original hybrid. Chromosomal variants were observed in three hybrids. The amphiploid ($2n = 4x = 28$) in the *T. tauschii* (Coss.) Schmal. × *S. cereale* L. regenerant was presumed to have originated from tetraploid primordial cells induced in the callus phase. A partial amphiploid regenerant with a chromosome number of $2n = 56$ was obtained from the *T. aestivum* by *A. elongatum* (Host) Beauvois ($2n = 42$) hybrid. One line of regenerants from the *T. crassum* (Boiss.) Pitch. and Hensl. by *H. vulgare* L. hybrid ($2n = 28$) exhibited chromosomal mixoploidy in somatic and meiotic cells, with chromosome numbers ranging from 28 to 92. After four regeneration cycles, the range in chromosome numbers had decreased to 46–58, i.e., approximating the amphiploid number. Thus, these studies have shown that callus culturing is a useful means of propagating sterile hybrids and in some cases of chromosome manipulation.

Hordeum cytogenetics

To initiate an interspecific gene exchange between *Hordeum bulbosum* L. and *H. vulgare* L., extensive crosses were made between 28 different genotypes of *H. bulbosum* (4*x*) and *H. vulgare* cultivar Betzes (4*x*). There were marked differences in the crossability of the *H. bulbosum* genotypes with Betzes. Following embryo culturing, there were also genotypic effects on embryo germination and finally on ratios of dihaploid and hybrid seedlings recovered. Hybrid plants generally had variable chromosome numbers in somatic tissue. Plants with more than 22 chromosomes remained stable, whereas those with less than 22 reverted to dihaploids following the elimination of *H. bulbosum* chromosomes.

Computer graphics

An interactive system using digital image processing techniques was developed for the quantitative study of plant chromosomes. The system was developed using somatic karyotypes of numerous *Hordeum* species and included measurements of chromosome length, area, centromere, and satellite positions. The straightened chromosomes were arranged in an ordered karyogram, and hard copy included the above measurements plus density profiles and photographs. This was a collaborative project with C. Merritt of the National Research Council of Canada.

Chromosome banding

Giemsa bands were obtained on *Thinopyrum distichum* (Thunb.) Löve (*Elytrigia disticha Agropyron distichum*). The banding pattern was characterized by fairly prominent terminal and subterminal bands. Comparative banding of the chromosomes of *Triticum durum* (cultivar Nordum) and the backcross of (*Triticum durum* × *Thinopyrum distichum*)2 × *Triticum durum* indicated that it was possible to distinguish between the chromosomes of *Thinopyrum distichum* and *Triticum durum*.

Giemsa bands have been obtained on the chromosomes of the diploid species *Hordeum stenostachys* Godron, *H. muticum* Presl., *H. setifolium* Parodi and Nicora, *H. cordobense* Bothm. et al., *H. flexuosum* Nees, *H. euclaston* Steud, and *H. pusillum* Wutt. Each species has a characteristic banding pattern, differing in the number, location, and intensity of the bands.

Bromus cytogenetics

The diploid species *Bromus variegatus* Bieb. was crossed to *B. inermis* Leyss (4*x*, 8*x*). Chromosome pairing in the triploid ($2n = 3x = 21$) hybrids fits a 2:1 genomic model of chromosome pairing, which suggested that *B. variegatus* contained a modified A or B genome. However, the trivalent frequency was low (0.4 per cell) in the pentaploid hybrid from *B. variegatus* × *B. inermis* (8*x*) indicating that the variegatus genome (V) was differentiated enough to allow preferential pairing in the genomes of octoploid *B. inermis* in the pentaploid (VAABB) hybrid.

ENTOMOLOGY

Population dynamics

Alfalfa weevil. Populations of the alfalfa weevil increased throughout the Bay of Quinte area during 1984. Continuing a trend that began in 1983, survival of the pest increased to its highest levels in a decade. Life table data showed that attacks on gravid females by wasps of first-brood *Microctonus aethiopoides* (Loan) reduced egg deposition by only 29% compared with 34%, the average for the previous 6 yr. Disease infections caused by *Erynia* spp. killed 57% of the feeding larvae versus 78%, and 2% of the cocooned stages versus 29%. *Bathyplectes anurus* (Thom.) claimed 8% of the prepupae, but only 2% of the emerging adults were parasitized by *M. colesi* (Drea) versus 19%, and wasps of second-brood *M. aethiopoides* attacked only 14% of the remainder versus 30%. This population release reflects the delayed density-dependent behavior of the *Microctonus* parasites and pathogenic fungi, and generation survival (20%) rivalled that observed during the early 1970s, when neither was present. This foreshadows greatly increased numbers for 1985.

Further evidence of a bivoltine strain of the weevil appeared in 1984. Approximately 8% of the summer adults did not aestivate and became reproductive in late August, laying a total of 572 eggs/m^2. A life table for this generation showed that frost and fungal disease destroyed 22% and 54% of the initial population, respectively. As a result, generation survival was only 2%.

Alfalfa blotch leafminer. Life tables for natural cohorts of all three generations were developed at representative sites across Ontario in 1985. In eastern Ontario, populations were low and declined for the 5th successive yr under continuing pressure by the parasitic wasp *Dacnusa dryas* (Nixon), which is the key influent; it destroyed 74% of the prepupae and, with other mortality factors, reduced generation survival to 1%, the lowest level in a decade. In central Ontario, where the wasp is newly established, leafminer populations were low to moderate, and generation survival averaged 4%. In western Ontario, where the parasite is absent, leafminer populations reached 36 000 maggots per square metre and predation of the larvae by nabids was the principal mortality factor; survival averaged 7%.

Eggs and first-instar larvae of *D. dryas* are occasionally encapsuled in hemocytes of the host maggot. During the late 1970s, when leafminer populations were high throughout eastern Ontario, rates of encapsulation were too low to be quantified. However, with the decline in leafminer populations, rates of encapsulation have increased steadily and now appear to be an inverse function of host density. This phenomenon has important ramifications for survival of both host and parasite.

Integrated pest management (IPM)

A computer mapping software program was developed for alfalfa IPM in southern Ontario. Documented under the acronym MEDIMAP, the package is implemented through the Agriculture Canada VAX 11/780 computer and uses temperature data from representative Ontario sites to produce a graphic display of weevil, leafminer, and crop development as they occur within the province. The package is available on-line to agencies throughout Ontario and is a valuable adjunct to the SIMWEEVIL–SIMABL monitoring system currently in use.

In 1984, IPM scouting activities were carried out on farms located in 10 counties across southern Ontario. Further releases of *D. dryas* were made using wasps propagated in the ORS nursery; recoveries of the parasite have now been made from 15 counties.

Honey bees

Studies are aimed at developing improved methods for controlling the organisms that cause American foulbrood disease (AFB), *Bacillus larvae* (White), and chalkbrood disease (CD), *Ascosphaera apis* (Maassem ex Claussen) Olive and Spiltoir, in honey bees. Disease-free hives were inoculated with purified spore suspensions and treated with specific bacteriophages (AFB), or citral was evaporated into the hives at the rate of 10 mL per day (CD). Infections by AFB occurred in only 30% of the larvae inoculated. However, the citral repelled the adult bees, indicating that a lower concentration of this pheromone was required.

A simplified system was developed for detection of the parasitic bee mite *Acarapis woodi* (Rennie), which has recently been found to be enzootic in the United States and is causing considerable concern to Canadian beekeepers. The method involves removal of the pronotum to expose the major tracheae, which then can be rapidly excised and assayed for presence of the pathogen.

FORAGE CROPS

Corn

Six new corn hybrids were supported for licensing: OX741, OX737, and OX768 in

Ontario; OX693 in the Atlantic Provinces; OX701 in Manitoba and Quebec; and OX733 in Alberta. The hybrids for Ontario [2600-2700 corn heat units (CHU)] are three-way (3W) and double crosses, thus ensuring economical seed production. They have good silage and grain yields. OX693 (3W) has superior stalk quality and was licensed in the Atlantic Provinces for silage production with a good performance index. OX701 (3W for 2250-2300 CHU) was a very stable performer on the eastern prairies and in the cooler regions of Quebec. In Alberta, OX733 is an early single cross that is significantly earlier than the previous earliest checks. In addition, it has superior yield and stalk quality.

Developing lines were screened after artificial inoculation with *Gibberella zeae*, and with four egg masses of *Ostrina nubialis*, and grown at high population density. Further selection was carried out for cold tolerance (10°C).

Experiments have been initiated on genetic variability in tolerance of low-temperature germination in maize. Seed from 12 populations, ranging from conventional corn belt to high altitude tropical land races, are being evaluated for their ability to extend the radical and cotyledon up to first-leaf emergence at low temperature. Comparisons have been made over a range of temperatures. The ultimate goal is to identify populations and individuals capable of germinating under cooler conditions.

Pathology. Considerable damage occurred in several breeding lines as a result of infection by *Alternaria* sp. The symptoms appeared early in the growing season during a period of wet cool weather and persisted through the summer. Severity of the disease varied from no infection in some lines to complete necrosis in others, suggesting that susceptibility was under genetic control. *Puccinia sorghi* Schw. occurred on several corn hybrids and breeding lines in Ottawa in 1984. Symptoms varied in severity, and very few plants at ORS were immune. Investigations are in progress to determine if this is a new race of the rust. Lethal leaf spot, a condition apparently controlled by a single recessive gene, was encountered in a single breeding line.

Alfalfa

Three new alfalfa (*Medicago sativa* L.) synthetics (FAR 14/1, Poly Sc 2, and COMSEL) were recommended for licensing by the Ontario Forage Crops Committee (OFCC) on the basis of dry matter (DM) production superiority and resistance to bacterial wilt (BW), *Corynebacterium insidiosum* (McCull.) H.L. Jens., and phytophthora root rot (PRR), *Phytophthora megasperma* Drechsler f. sp. *medicaginis*. These are the first alfalfa cultivars to be bred in Canada against these diseases. FAR 14/1 has been named Olinda, and seed will be available to farmers by 1987. Newly selected clones with genes resistant to BW, PRR, and verticillium wilt (VW), *Verticillium albo-atrum* Reinke & Berth., are being used to produce alfalfa synthetics.

Experiments to study the benefits of nitrogen fixing forage legumes on grasses in a mixed or rotated cropping system were begun. They will measure the nitrogen (N) transfer from legumes to associated grasses and N benefit from legume residues to subsequent nonnitrogen-fixing crops.

Nitrogen fixation and N transfer were determined under field conditions, by using ^{15}N dilution and acetylene reduction techniques. Alfalfa, birdsfoot trefoil, red clover, bromegrass, tall and red fescues, and timothy were grown in different grass-to-legume ratios and clipping frequencies so that conditions were optimal for N transfer in the greenhouse and field. The inclusion of legumes in the legume–grass mixtures improved both forage quantity and quality. N transfer was enhanced by increasing the proportion of legume to grass and the frequency of clipping. Both direct excretion through living alfalfa nodule-root systems and decomposition of dead nodules and alfalfa plant tissues may be involved.

A study was initiated to investigate the mechanism of alfalfa root exudation in relation to nitrogen fixation and metabolism within plants under various environmental stresses. Nitrogenous compounds (ammonia, glutamate, serine, alanine, and aspartate) were excreted from alfalfa nodule-root systems. The excretions were stimulated by decreasing the photosynthate supply, which resulted either from clipping the shoots or shading.

Pathology. An isolate of *V. albo-atrum* from alfalfa survived a wide range of temperatures (–5 to 35°C) over 2 yr.

Soybean

Maple Isle, an early maturing soybean cultivar developed by ORS in cooperation with the Brandon Research Station, was released to pedigree seed growers in the spring of 1984. Maple Isle yields from 3 to 9% more than Maple Amber in the short-season areas of eastern Canada. In Manitoba and Alberta, yields are equal to those of Maple Amber. Maple Isle, unlike Maple Amber, is tolerant of the herbicide metribuzin, which is an important advantage on farms where weeds necessitate the use of metribuzin.

Another early maturing cultivar, Maple Ridge, was released by the Ottawa and Brandon research stations. Maple Ridge matures about 3 days earlier than Maple Amber and produces similar seed

yields. Compared with Maple Presto, the earliest maturing cultivar available in Canada, Maple Ridge is 5 days later in maturity and yields 20% more. This cultivar is particularly well adapted to those areas of Manitoba, Alberta, and Ontario that have a very short growing season. It is not adapted to the short-season areas of the Maritime Provinces, nor is it tolerant of the herbicide metribuzin.

Canatto, a new cultivar for the export market, was released by ORS. Natto is a fermented soy food produced in Japan that requires soybean seed about half the size of that from standard varieties. Canatto matures about 1 wk earlier than the previously licensed cultivar, Nattawa, and has slightly higher yields, much improved stem strength, and is tolerant of the herbicide metribuzin. Although its seed size is somewhat larger than that of Nattawa, its quality for natto production has been improved.

Pathology. Forty-four soybean [*Glycine max* (L.)] lines were tested against race 4 of the bacterial blight pathogen (*Pseudomonas syringae* pv. *glycinea*). Three lines (X446-2-B-19-2, X1345-76B, and X1365-9-B) showed considerable resistance to race 4, which is the most prevalent race in eastern Ontario. The distribution of bacterial blight (infection) in growers' fields appears to be nonrandom in the early part of the growing season and later turns to a regular pattern.

Grasses

The forage grass program is focused on cultivar development and the investigation of the genetics and breeding behavior of autopolyploid forages. The principal selection criteria for timothy and bromegrass are in vitro digestibility (IVD) and dry matter (DM) yield. Orchardgrass is being selected for pasture-related traits including resistance to frequent defoliation, mid-summer DM yield, and winterhardiness.

Winter-hardy germ plasm of switchgrass (*Panicum virgatum* L.) is being evaluated for its potential as a midsummer pasture species. This species has a C-4 type photosynthetic system and accumulates DM most rapidly during the hot summer months, when temperate species are least productive. Several crosses made among agronomically desirable clones are being advanced to the second generation.

A wide variation among ramets of individual timothy genotypes was found when plants were evaluated for DM yield under intense inter-plant competition (100 plants per square metre). The performance of individual plants was not closely related to that of neighboring plots. Further studies on error reduction in simulated swards are in progress.

Theoretical models of mating designs that will maximize heterozygosity in autopolyploids are being investigated. A computer program was developed to generate the allelic structure of progenies from crosses of individual genotypes or populations.

GENETIC ENGINEERING

Developmental plant physiology

In commercial alfalfa (*Medicago sativa* L.), the ability to form callus and regenerate into whole plants through somatic embryogenesis is strongly influenced by genotype. Two land race breeding sources, Ladak and *M. falcata* L., were found in the genetic background of most of the highly responsive cultivars. These selected cultivars were almost exclusively western creeping-rooted types. In vitro techniques for *Medicago*, *Melilotus*, and *Trigonella* species were improved significantly in the areas of shoot tip and stem node culture, somatic embryo induction, somatic embryo germination, and cell suspension culture.

Improved methodology for cold hardening alfalfa suspensions was developed in collaboration with the Chemistry and Biology Research Institute. Treatment of cells with the plant growth regulators 2,4-D and abscisic acid, followed by exposure to low temperature (−2°C), resulted in the development of freezing tolerance up to −15°C. These tolerance levels were similar to those observed in the field with whole plants.

Viable protoplasts in high yields were isolated from cell suspension cultures of *Brassica napus* L. cultivar Jet Neuf and *B. nigra* L. Cell division in the protoplast cultures was initiated at frequencies in excess of 20%, and macroscopic colonies formed at frequencies of up to 10%. Embryogenesis was induced in the protoplast-derived cell colonies. In the case of *B. napus* cultivar Jet Neuf, plantlets have been regenerated from the embryos.

Thin layers of epidermal tissue have been successfully used as a direct source of protoplasts in *B. napus* cultivar Westar. Colony formation has been obtained at frequencies of 1%, and shoot bud development has been induced by cytokinin treatment.

Experimental haploidy

A doubled haploid line of *B. napus* obtained by anther culture was used in tests to optimize nutrient supplementation of anther donor plants.

Plants grown in vermiculite and supplemented with slow release fertilizer [i.e. Nutricote 40 (Chisso-Asahi)] yielded up to three embryos per cultured anther. A survey of *B. napus* and *B. campestris* cultivars was undertaken to identify strains highly responsive to anther culture. *Brassica napus* cultivar Topas gave consistently high yields of embryos. Experiments to establish pollen cultures for genetic engineering studies have been initiated with this cultivar.

Somatic cell genetics

Brassica nigra suspension cultures were shown to be at least 10 times more sensitive to the growth-inhibiting effects of the amino acid analogue 5-methyl-tryptophan (5 MT) than all other species reported in the literature. Conversely, these same cultures were 5 and 15 times more resistant to L-azetidine-2-carboxylic acid and to S-2-aminoethyl-L-cysteine, respectively. Four variant cell lines of *B. nigra* capable of growing at normally inhibitory concentrations of 5 MT were isolated. The tolerant variants occurred in the sensitive parental population at a very low frequency (1.25×10^{-7}). Sequential exposure of the variant lines to progressively higher concentrations of 5 MT produced cultures capable of growing at 750 times the normal growth-inhibitory concentration. Long-term culture tests indicated that only a portion of the resistance was stable in the absence of 5 MT. Only this component of the resistance was considered to have a true genetic basis.

Twenty-five somatic hybrid lines of *Solanum melongena* L. (eggplant) + *S. sisymbriifolium* Lam. were characterized through cytological, morphological, and biochemical analyses. All hybrids were aneuploids and contained *S. sisymbriifolium* chloroplasts. Collaborative tests carried out in the U.S. Department of Agriculture Vegetable Research Laboratory, Charleston, S.C., indicated that all hybrids tested were resistant to the root-knot nematode, a serious pest of eggplant. Preliminary attempts at selfing or backcrossing the hybrids have failed.

Plant molecular genetics

Detailed analysis of alfalfa protoplasts in liquid culture revealed that all living cells underwent nuclear division, but most could not form cell walls or undergo more than one cell division. The plating efficiency of alfalfa protoplasts was increased to 20%, which represents a 300- to 400- fold improvement. As a result of this development, as few as 200 protoplasts could be manipulated in each transformation experiment. Microinjection of Ti plasmids into nuclei yielded extremely high transformation frequencies (28%) using nopaline synthase activity as a marker for the expression of T-DNA.

Methods have been developed for measuring absolute plating efficiency by following individual protoplasts embedded in low melting temperature agarose. This has permitted quantitative measurements of the influence of organelle-specific fluorescent dyes on viability. Based on these studies, a technique for identifying mitochondria in living plant cells was developed; it has been employed in research involving the transfer of cytoplasmic male sterility (a mitochondrial trait) into *Brassica* species.

ORNAMENTALS

Plant breeding

A new winter-hardy climbing rose, Henry Kelsey, was registered. Henry Kelsey combines hardiness with free and recurrent flowering, a high level of resistance to mildew, *Sphaerotheca pannosa* (Wallr. ex Fr.) Lév., and field resistance to blackspot, *Diplocarpon rosae* Wolf. It survived the winters in locations with more severe climates than in Ottawa. A strain of *Rosa rugosa* Thunb., obtained from seeds collected in Japan, was highly resistant to the two-spotted spider mite, *Tetranychus urticae* Koch, and the strawberry aphid, *Chaetosiphon fragaefolii* (Cockerell). It was released as genetic stock under the name Rugosa Ottawa. The combined resistance to two insect pests is rare in plants. It has not been reported in roses. Rugosa Ottawa is also highly resistant to blackspot and mildew. A new winter-hardy weigela, Rumba, was registered. Rumba is a vigorous dwarf shrub that flowers repeatedly. It survived winters in locations with more severe climates than Ottawa.

Pathology

Phomopsis juniperovora Hahn isolated from red cedar (*Juniperus virginiana* L.) and white cedar (*Thuja occidentalis* L.) in eastern Ontario was pathogenic on *T. occidentalis*. At 18–20°C and 100% relative humidity for 192 h, severe dieback resulted. *Nectria* sp. and *Cytospora* sp. were isolated from spruce (*Picea abies* L. Karst. and *P. pungens* Engelm.) and pine (*Pinus resinosa* Ait. and *P. strobus* L.). Spruce inoculated with *Cytospora* sp. developed necrotic lesions, but *Nectria* sp. failed to cause symptoms. When soilless mixtures infested with *Rhizoctonia solani* Kühn were seeded with 10% soil containing *Trichoderma viride* Pers. ex Fr., geranium (*Pelargonium* × *hortorum* L.H. Bailey) seed germinated and grew to the transplanting stage with-

out damping-off. The addition of *T. viride* in wheat bran culture to soilless mixtures also provided good protection from *R. solani*. Cut-flower production of *Chrysanthemum morifolium* (Ramat.) Hensl. was decreased 24% in soil infested with *Pythium aphanodermatum* (Edson) Fitzp. and 8% in soil infested with *R. solani*. Stem length and flower size also were decreased by either fungus, although neither caused death of the plants.

Floriculture

Donor plant development influenced micropagation of *Begonia* × *hiemalis* (Fotsch). Leaf expansion at the time of petiole excision significantly affected the in vitro response. Explants taken at early and mid-exponential phases responded well, but at late exponential, shoot production was reduced by 80%. Relatively few adventitious shoots developed to a stage that allowed efficient rooting and establishment. Shoot elongation of adventitious buds was significantly increased by gibberellic acid (10 mg L^{-1}), resulting in a three-fold increase in production of large shoots that could be rooted directly under intermittent mist. Flower induction of *Streptocarpus nobilis* (C.B. Clarke) was temperature sensitive. Plants given short days (SD) at 25°C subsequently flowered in noninductive photoperiods. Plants given SD at 15°C remained vegetative after transfer to 25°C. Leaf tissue was the site of temperature-sensitive photoinduction. Leaf explants could be photoinduced at 25°C, but explants given SD at 15°C produced only vegetative shoots when transferred to noninductive photoperiods at 25°C. The photoinduced state was stable at 15°C, which suggests that the photoinductive process is temperature sensitive.

Nursery research

Growth responses to variable levels and sources of phosphate fertilizer and mycorrhization with *Glomus* fungi in a container production system were analyzed for five woody ornamentals. Rock phosphate treatments exhibited greater growth responses and levels of mycorrhizal infection than superphosphate treatments. A combination of 50 ppm rock phosphate and mycorrhizae was as effective as higher rates of phosphate fertilization. Substitution of rock phosphate for superphosphate in container production systems would allow introduction and maintenance of mycorrhizae, and lower levels of phosphate fertilizer application and runoff. Mycorrhizae were successfully introduced into nursery production systems during vegetative propagation, and mycorrhized cuttings were overwintered in cold storage without loss of mycorrhizal infection or infectivity.

Ornamental gardens

Five species of annuals were evaluated in 1984. The top-scoring cultivars were as follows: impatiens (Sherbet Mix, Super Nova Coral, Super Elfin Blush); lobelia (Crystal Palace, Rainbow Cascade, Emperor William); nicotiana (Nicki Rose, Nicki Pink, Nicki Bright Pink); nasturtium (Whirlybird Gold, Whirlybird Tangerine, Whirlbird Mahogany); and gazania (Fire Emerald, Sundance Mix, Rainbow Mix).

PLANT GENE RESOURCES

Plant gene information

A trait inventory report on the 1375 stocks in the Canadian Tomato Genetic Resources Collection was published in 1984. It lists cultivars and genetic stocks in the collection under 78 traits or descriptors. A microfiche version is available on request. Descriptions for a total of 3827 stocks of barley, tomato, and wheat were entered in their respective crop information banks in 1984. They represent about 23% of the Canadian Crop Genetic Resources Inventories (16 500 stocks) held at present at the Plant Gene Resources of Canada (PGRC) office. The information on each stock is stored in the respective crop data banks, and computer trait inventories on each crop are available.

Conservation

Almost 78 500 stocks of various plant species are being preserved under controlled conditions at the PGRC office. A total of 214 apple stocks are preserved in clonal repositories located at six Agriculture Canada research stations across the country. Canada is a key participant in the program of the International Board for Plant Genetic Resources for the preservation of international collections of valuable germ plasm.

Collections of pearl millet, oats, barley, rapeseed, and mustard are preserved in the seed stores in Canada. Countries represented in the collections include Benin, Bhutan, Botswana, Burkina Fasso, Burundi, Cameroon, Central African Republic, Gambia, Jordan, Kenya, Malawi, Mali, Mozambique, Niger, Nigeria, Pakistan, Senegal, Somalia, Sudan, Syria, Togo, Yemen, Zambia, and Zimbabwe.

Exchanges

In 1984, activities in connection with exchanges of genetic stocks and cultivars resulted in 314 exchanges with individuals in 42 countries for a total of 8640 accessions.

Newsletter

The PGRC Newsletter, published semiannually, reports informally on activities concerning gene resources. It has a mailing list of 800 568 in Canada and 232 in 38 other countries.

EXPERIMENTAL FARM KAPUSKASING, ONTARIO

Forage preservation

Orchardgrass cut at the 10% heading stage was ensiled in laboratory silos to compare the effectiveness of pulp and paper industry by-products as silage preservatives. Three repetitions of each treatment were evaluated 35 days after ensiling. Formic acid and no preservative were used as positive and negative controls. The product from Mill No. 1 was used at 23 kg to the wet tonne of silage, and softwood and hardwood by-products from Mill No. 2 were used at 23 kg and 12.5 kg to the wet tonne.

Ammonia level, pH, and percentages of soluble sugars, lactic acid, acid detergent fiber (ADF), neutral detergent fiber (NDF), and dry matter were compared. There were no significant differences in percentages of NDF, lactic acid, and dry matter between treatments. The percentages of ADF and soluble sugars were significantly different at the 5% level only. The by-products from Mill No. 2 at the higher rates caused a significant improvement in ADF value over the control (30.3% and 30.8% versus 33.1%). The hardwood by-product from Mill No. 2 was equal to formic acid as a preservative for soluble sugars. There were highly significant differences in pH and ammonia level between treatments. Although the direct acidifying ability of the products was low compared with that of formic acid, the silage made with these by-products had a lower pH than that treated with formic acid. The ammonia level in the silages made with by-products from Mill No. 2 was significantly higher than in any other treatment. However, since these by-products contain ammonia, this was not necessarily an indication of protein degradation. These results show that wood by-products, particularly those originating from hardwoods, result in improved fermentation.

Cereal management

Over the last 3 yr (1982, 1983, 1984) between 11 and 17 varieties of barley were treated with the growth regulator Cerone (Union Carbide) to evaluate its ability to reduce straw length and improve lodging and grain yield. In the 11 cultivars evaluated over 3 yr, reduction in straw length varied from a low of 4.3 cm for the cultivar Bruce to a high of 13.0 cm for Peguis. In 1 yr, no lodging occurred because of growing conditions, but in the other 2 yr, lodging was evident. On a scale of 1–9, lodging resistance was rated as high as 3.0 in some cultivars to 1 in others. Birka was the only cultivar that gave a significant grain yield reduction when sprayed with Cerone. The regulator, when applied to the other cultivars, either increased grain yield or had no effect.

EXPERIMENTAL FARM THUNDER BAY, ONTARIO

Potato production program

In 1984, the Ontario regional potato trials were replaced with a program for the multiplication of breeders' lines and varieties. In May 1984, 22 families of various breeders' lines and virus-free tubers from 18 licensed varieties were planted for multiplication.

In early July, five aphid traps were located in the potato blocks. The first aphid was recorded on 23 July with weekly sampling carried out until 1 September. Data were not collected from traps on 23–25 July or 3–9 August, because of heavy thunderstorms. The total number of aphids for the five traps were as follows: potato aphid, *Macrosiphum euphorbiae* (Thomas), 9; green peach aphid, *Myzus persicae* (Sulzer), 194; foxglove aphid, *Aulacorthum solani* (Kaltenbach), 45; buckthorn aphid, *Aphis nasturtii* Kaltenbach, 36. The largest concentration of one species occurred on 31 July, when 40 green peach aphids were counted.

A total of 143 tubers were selected from the breeders as suitable for continuation in the breeding program. The multiplication program was inspected for virus, blackleg, early and late blight, and rhizoctonia by Agriculture Canada inspectors on three occasions. Each variety received an Elite 1 tag.

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Research Station, Vineland Station, Ontario

PROFESSIONAL STAFF

D.R. Menzies, BSA, MSc, PhD	Director
E. Piil	Administrative Officer
M.A. Fraumeni,[1] BA, MLS	Librarian

Entomology

D.J. Pree, BSA, MSc, PhD	Head of Section; Toxicology
A.B. Stevenson, BSc(Agr), PhD	Vegetable pest management
A.B. Broadbent, BSc, MSc, PhD	Ornamental entomology
E.A.C. Hagley, BSc(Agr), MSc, PhD	Fruit pest management
H.M.A. Thistlewood,[2] BSc, MSc	Acarology
R.J.M. Trimble, BSc, MSc, PhD	Bioclimatology

Nematology, Chemistry, and Computer Science

J.W. Potter, BSA, MSA, PhD	Head of Section; Nematode ecology and chemical control
M. Chiba, BSc, DSc FCIC	Residue chemistry
B.D. McGarvey, BSc, MSc	Chemistry
T.H.A. Olthof, Ing, BSc(Agr), PhD	Host–parasite relations
J.L. Townshend, BSc, MSc, DIC	Nematode ecology
J. Yee, BSc, MSc, PhD	Mathematics and computing

Plant Pathology

W.R. Allen, BA, PhD	Head of Section; Fruit and soil-borne viruses
A.R. Biggs, BSc, MSc, PhD	Tree fruit diseases
R.F. Cerkauskas, BSc, MSc, PhD	Vegetable diseases
J.A. Matteoni, BSc, MSc, PhD	Ornamental pathology
J. Northover, BSc, PhD, DIC	Fruit mycology
A.A. Reyes, BSA, MSA, PhD	Vegetable mycology
L.W. Stobbs, BSc, MSc, PhD	Grapevine viruses

Smithfield Experimental Farm, Trenton, Ont.

S.R. Miller, BSc, MSc, PhD	Superintendent; Pomology
W.P. Mohr, BSA, MSA, PhD	Food Processing
J.G. Metcalf	Tomato breeding
N.J. Smits, BSc	Vegetable management
J. Warner, BSc, MSc	Pomology

Extension Services[3]

D. Ridgway	Fruit and vegetable crops

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[1]Seconded from Libraries Division, Finance and Administration Branch.
[2]On educational leave.
[3]Ontario Ministry of Agriculture and Food, Trenton, Ont.

INTRODUCTION

The Vineland Research Station serves the horticultural industry with comprehensive crop protection research that is organized under four programs: tree fruits, grapes and berries, vegetables, and ornamentals. Some work is also done on forages and tobacco. Scientific disciplines represented at the station include entomology, acarology, ecology, mycology, virology, bacteriology, nematology, pesticide residue chemistry, toxicology, computer science, and engineering. The Smithfield Experimental Farm, located near Trenton, is administratively linked to this station and carries on horticultural production and processing research, as well as pest control programs in collaboration with Vineland.

This report summarizes some of the research results from the station in 1984; more detailed information can be obtained from the publications listed at the end of the report. For more information on these and other research projects, or for copies of this report, please write to the Director, Research Station, Research Branch, Agriculture Canada, Vineland Station, Ont. L0R 2E0.

D.R. Menzies
Director

TREE FRUITS

Insects and mites

Biological control. Inundative releases of a strain of *Chrysopa carnea* Stephens resistant to organophosphorous insecticides resulted in suppression of the apple aphid, *Aphis pomi* De Geer on dwarf apple trees. The greatest reduction in number of aphids occurred in plots treated with azinphosmethyl for control of other pests. This suggests that augmentation of natural *C. carnea* populations will provide an alternative or a supplemental strategy for management of *A. pomi* populations on dwarf apples.

Trichogramma minutum Riley and *T. pretisoum* Riley were recovered in several unsprayed and commercial apple orchards in Ontario. Parasitism was lower in commercial orchards but was highest in July and August in both types of orchard. *Trichogramma* spp. were not recovered in commercial orchards in the spring, despite their occurrence in unsprayed orchards. Manipulation or augmentation (or both) of natural parasite populations commencing in late May to early June might therefore result in higher parasitism of eggs of the codling moth, *Cydia pomonella* Linnaeus, and other lepidopteran pests of apple present at that time.

Chemical control. Sprays of permethrin and the insect growth regulators diflubenzuron and alloxyotin gave good control of the codling moth, *Cydia pomonella*, and the spotted tentiform leafminer (STLM), *Phyllonorycter blancardella* (Fabricius). However, leafminer populations were reduced by the insecticides to levels too low to sustain the parasite *Pholetesor (=Apanteles) ornigis* Weed. Inundative releases of *P. ornigis* in untreated plots increased parasitism in first-generation STLM from <2% to ca. 38%. A balance is needed between control of STLM with chemicals and maintaining levels of parasitism by *P. ornigis*. Preliminary tests with several permethrin concentrations have given encouraging results.

Resistance in the STLM to synthetic pyrethroid insecticides was higher in samples from Northumberland County (ca. 10×) versus ca. 6× in samples from Norfolk County. Where higher levels of resistance were detected, growers were advised to use carbamates such as methomyl rather than pyrethroids. The form of the resistance is probably similar in both areas since insecticide–synergist (both oxidase and esterase blockers) combinations were ineffective against both populations. Tests in Norfolk County have shown that adjustments in spray timing can be useful in overcoming low levels of resistance.

Larvae of the predaceous common green lacewing, *Chrysopa carnea*, from local orchards are resistant to synthetic pyrethroids and organophosphorous insecticides. Resistance is primarily metabolic in form, caused by increased levels of esterase that enhance hydrolysis of synthetic pyrethroids and malathion. Multifunction oxidase activity is also responsible for detoxification of both synthetic pyrethroids and most organophosphorous insecticides. In vivo assays with oxidase and esterase blockers suggest both systems are equally important in the detoxification of synthetic pyrethroid insecticides.

Ecology. *P. ornigis* is an endoparasitoid of larvae of STLM, an important pest of apple in Michigan, New York, and Ontario. Sticky-trap catches of *P. ornigis* indicated the following: color had a significant effect on the total number of parasites caught (best with maximum reflectance between 550 and 600 nm); the relative

attractiveness of the colors did not change during or between periods of activity; and there were no consistent differences in the relative attractiveness of the various colors to males and females. During 1984, males consisted of more than 75% of all parasites trapped during each of the three yearly periods of activity, although the sex ratio of the adult population emerging in the same orchard during two of these periods of activity was approximately 1:1. The traps are more effective at trapping male than female *P. ornigis*.

Predator–prey relationships. Serological procedures to identify predator (parasite)–prey relationships produced antisera to codling moth, oriental fruit moth, obliquebanded leafroller larvae, and to STLM and its parasite, *P. ornigis*. Because of the high sensitivity needed to detect eggs or larvae of *P. ornigis* in parasitized STLM, a modified technique was developed using peroxidase-labeled goat antirabbit IgG antiserum for precipitin zone resolution. This change increased sensitivity ca. 15 times and may be the most sensitive and reliable test available when cost, time, safety, and ease of use are considered.

Nematodes

Biology. *Meloidogyne microtyla*, first described in 1975, was shown to reproduce on 62 plant species out of 87 species tested from 21 plant families. Grasses were the best hosts, including some grasses used as orchard cover crops and others important for golf greens and fairways. The nematode is of concern because of its ability to damage orchard cover-crop grasses and because it is distributed in apple-growing areas where these grasses are used to suppress populations of lesion nematodes.

Vectors. The vector potential of populations of *Longidorus diadecturus* Eveleigh & Allen and *L. breviannulatus* Norton & Hoffman for the peach rosette mosaic virus (PRMV) and the tomato blackring virus (TomBRV) was assessed in the greenhouse. Both viruses were detected in both nematode species after they fed on infected *Chenopodium*, *Petunia*, and *Cucumis* species, but there was no indication that either nematode species is a significant vector of the TomBRV. *Longidorus diadecturus* was shown to be an efficient vector of the PRMV, while *L. breviannulatus* was not.

Diseases

Apple scab, Venturia inaequalis. Several materials were evaluated for control of apple scab under field conditions. DPX H 6573 (Dupont) gave best control (1.7% infection), followed by Baycor + Captan (5.0%), Captan (9.2%), Baycor (10.0%), CGA-64251 (Ciba-Geigy) (11.7%), CGA-71818 + Manzate (20.8%), and control (85.0%). Sprays were applied in a combination protection–eradication schedule. The eradicant activity of sterol-inhibiting compounds could not be assessed because of overlapping periods of infection.

In 1984 the apple scab fungus was resistant to Benlate in 45 orchards, to Cyprex in 12 orchards, and to both fungicides in a further 9 orchards of the 145 locations examined since 1978. Benlate-resistant brown rot, *Monilinia fructicola*, was found in 83% of the 35 cherry and peach orchards sampled between 1982 and 1984. The number of known resistant locations has increased substantially between 1983 and 1984. However, no low-level resistance of brown rot to the newly introduced fungicide Rovral was found. Resistance to Benlate and Cyprex has placed greater dependence upon captan and several dithiocarbamate fungicides for use in multifungicide programs designed to delay the development of fungicide resistance.

Peach canker, Leucostoma persoonii, L. cinta. Conventional histochemistry and epifluorescence illumination, together with fluid diffusion tests, were used to evaluate the presence of impervious tissue in peach bark.

Boundaries to fluid diffusion formed in an area of hypertrophied cells approximately 1 mm internal to the surface of a bark wound prior to the formation of new suberized periderm. Suberin lamellae were found on the internal wall surface of the impervious cells, and the exclusive association of suberin with the inhibition of fluid diffusion in the impervious tissue was determined. Freezing or chemical fixation did not affect test results.

Formation of suberized tissue prior to phellogen regeneration is being tested as a criterion for selecting peach genotypes with rapid wound response capacity. This method is faster than current callus formation or wound closure assessment.

Brown rot, Monilinia fructicola. Ten peach varieties were collected, wounded, and inoculated with conidia of the brown rot fungus. The broad range in mean lesion growth rate indicated the presence of resistance in peach flesh to fungal colonization. Varietal resistance appears correlated with maturity date, i.e., early varieties support slower fungal colonization rates than later varieties. Increased brown rot in later maturing cultivars has been assumed to be related to build-up of inoculum on the earlier maturing cultivars. Our data support this assumption in that earlier

cultivars produced significantly greater numbers of spores per fruit.

GRAPES AND SMALL FRUITS

Diseases

Control of bunch rot with plant growth regulators. The prebloom application of gibberellic acid (GA_3) to Seyval Blanc grapevines increased bunch length and reduced bunch tightness with no adverse effect on berry set or bunch weight. The more open bunches were less prone to spoilage by sour rot and by *Botrytis* bunch rot. On the tight-bunch cultivar Johannisberg Riesling, GA_3 increased bunch length, but reduced berry set and bunch weight. Furthermore, J. Riesling vines treated in 1983 showed delayed shoot development and severely reduced fruitfulness in 1984.

Tomato blackring virus (TomBRV). In 1978 TomB was introduced into the Niagara peninsula in a shipment of Pinot Chardonnay, clone 95, imported as virus-free stock from France. Infection occurred only in single vines within rows, with no evidence of virus transmission to adjacent vines. Serological tests were positive against the G and B strains of TomBRV obtained from Germany and Scotland, respectively, and characteristic symptoms were produced on indicator plants. Infected vines were removed from the vineyard and destroyed, and the remaining vines will be monitored over the next 2 yr to identify any additional infections. Because the nematode vector was not present, it is likely that the virus will be eradicated by these measures.

The host ranges of TomBRV and grapevine Joannes-Seyve virus have been shown to be identical, and a strong serological relationship exists between the two viruses. Protein and RNA analyses demonstrate strong similarities. From these studies, grapevine Joannes-Seyve virus was determined to be a strain of TomBRV.

Virus diagnostic procedures. Improvements were made to two commonly used virus diagnostic procedures. The sensitivity of the immune electron microscopy procedure was significantly increased by magnetically rotating serum-activated nickel grids on the sample using a magnetic stirrer. This bound greater numbers of virus particles to the grids, thereby reducing diagnostic time. A modified enzyme-linked immunosorbent assay (ELISA) was developed that used conjugate solidified in a gelatin matrix within sample wells that were precoated with antibody. The preformed plates required only the addition of sample followed by substrate and could be stored for extended periods without significant decrease in sensitivity or specificity. This modification is faster, enhances reagent stability, and improves the recognition of virus by significantly reducing healthy baseline reactions.

VEGETABLES

Insects

Control of the carrot rust fly, Psila rosae (Fabricius). Granular carbofuran, applied in the seed furrow to control first-generation carrot rust fly (CRF), is no longer effective. In 1984, six organophosphorous insecticides were tested, at the Holland Marsh, in V-belt or precision seeding trials (or both) with active ingredient (a.i.) at 1.1 and 2.2 kg/ha. Disulfoton (Di-Syston 15G), fonofos (Dyfonate 10G), and fensulfothion (Dasanit 15G) were not sufficiently effective or were too phytotoxic to consider for further testing. Chlorfenvinphos (Birlane 10G), a candidate for registration, was not effective at the low rate, and only moderately so at the high rate. Phorate (Thimet 15G) was effective at both rates, but phytotoxic with a.i. at 2.2 kg/ha. Terbufos (Counter) and an insect growth regulator, Trigard, appeared worthy of further testing.

Biology of the carrot rust fly. Celery is a host of the carrot rust fly (CRF), but normally no economic injury results from infestations of celery by CRF in the Holland Marsh. Experiments using emergence cages placed over celery plants or harvested rows showed that early-season celery, exposed to the overwintering generation of CRF, was a source of adults that can attack nearby carrots. The number of adults captured on sticky traps, and the percentage of the carrot crop damaged at harvest, were greater in carrots adjacent to celery than in similar plots remote from early-planted celery.

Monitoring the carrot weevil, Listronotus oregonensis (LeConte). Experimental monitoring of the carrot weevil (CW) in the Holland Marsh from 1980 to 1984 has shown that the presence of CW in commercial carrot fields can be detected at population levels below those causing economic crop damage. Weevils are monitored using 10-cm sections of carrot placed in the soil of carrot fields soon after seeding and checked every 3–4 days for the presence of egg cavities. Where the maximum mean number of cavities per section per day was less than 0.3–0.5, and if not more than 50% of the root sections contained cavities, damage to carrots at harvest was usually less than 2.5%, and spraying specifi-

cally for CW control was not justified economically.

Nematodes

Chemical control. In a potato microplot study, Vydate L (oxamyl) was applied to control *Pratylenchus penetrans* in Russet Burbank potatoes. Using in-furrow preplant treatments or foliar sprays (or both), oxamyl was shown to be effective, with yield increases of up to 73%, depending on treatment method and application rate. Residues of oxamyl in both tubers and soil at harvest were below detectable limits in all samples tested.

HPLC method to determine oxamyl residues in potato. An effective and simple HPLC method to determine oxamyl residues in potato tubers was developed. Residues are extracted from tubers with methanol, partitioned into dichloromethane, and cleaned up using a SEP-PAK florisil cartridge. The minimum detectable concentration of oxamyl in tubers by this method is 0.01 μg/g. No oxamyl was detected in any tuber samples harvested after in-furrow or foliar applications of oxamyl (Vydate L), or both, at the recommended rates of 9 L/ha and 18 L/ha.

Diseases

Postharvest pathology. The pathogenicity of various fungi on stored celery [*Apium graveolens* L. var. *dulce* (Mill.) Pers.] and the effect of controlled atmosphere on this pathogenicity were investigated. The pathogenic fungal isolates were *Botrytis cinerea* pers. ex Fr. and *Sclerotinia sclerotiorum* (Lib.) de Bary; isolates found to be nonpathogenic were *Rhizopus stolonifer* (Ehr. ex Fr.) Vuill., *R. nigricans* Ehr., *Alternaria dauci* (Kuhn) Groves & Skolko, and several species of *Fusarium*, *Penicillium*, and *Helminthosporium*. All three isolates of *B. cinerea* tested caused severe disease on celery; the three isolates of *S. sclerotiorum* caused from slight to moderate disease. A controlled-atmosphere treatment with 7.5% CO, 1.5% O_2, and the remainder N_2 was more suppressive than treatments with 4% CO_2 1.5% O_2, and the remainder N_2 or 1.5% O_2 and the remainder N_2 and consistently suppressed the mycelial growth of both fungi on potato dextrose agar. Therefore, CO has the potential to control these diseases of stored celery.

Phoma canker of parsnip. *Phoma complanata* was identified as the causal agent of canker occurring on the petioles and roots, and of leaf spots, on parsnip (*Pastinaca sativa*). The pycnidial wall characteristics, the extent of linear mycelial growth, the cultural characteristics on oatmeal and malt agars, and its occurrence on the umbelliferous host distinguish *P. complanata* from other *Phoma* species. This is the first report of *P. complanata* on parsnips in North America.

Septoria on tomato. In Ontario this disease may be quite damaging if it occurs early in the growing season. The fungus was inoculated at various times on the early maturing, susceptible H2653 cultivar and on the late maturing, moderately susceptible and moderately resistant cultivars FM6203 and C37, respectively. Faster rates of defoliation and faster fruit ripening, as well as lower yields, were associated with inoculated plants as compared with fungicide-protected plants. Plants of FM6203 and C37 inoculated at the earliest time had yields that were 64% and 59%, respectively, those of fungicide-protected plants.

Anthracnose on cucumber. Anthracnose caused by *Colletotrichum orbiculare* can be one of the most destructive diseases of cucumbers. Peppi and Triple Mech cultivars were inoculated with the fungus at five different times during the season starting when fruit was 3–5 cm long. Disease severity, grade, and yield of fruit were determined, and because total yield does not relate directly to dollars per hectare, dollar values (1983) were applied to the various grades. Triple Mech cultivar yield losses due to anthracnose ranged from 7.0 to 12.1 t/ha or from $1200/ha to $2300/ha, respectively, compared with the fungicide-protected plants. Peppi cultivar had yield losses ranging from 1.8 to 11.1 t/ha or $115/ha to $2049/ha compared with the fungicide sprayed plants. Yield of Triple Mech was less than that of Peppi for similar inoculation times. Greatest yield losses were associated with mid and early inoculations.

Tomato spotted wilt virus (TomSWV). The thrips-transmitted TomSWV occurs asymptomatically in a number of glasshouse ornamental cultivars. Tomatoes, grown in succession or concurrently with infected ornamentals, had greatly reduced yields and were severely stunted if infected early. Infections throughout the production period caused fruit symptoms that were not always obvious on the green fruit but appeared during after-ripening in retail outlets. Inoculation of the recommended cultivars Buffalo, Centennial (CR6), Dombella, Dombito, Jumbo, Laura, Ohio MR13, Vendor, and Vision resulted in moderate to extremely severe fruit lesions, deformity, and size reduction, which varied with the cultivar and time of inoculation. Resistance to the virus was not apparent. Eradication of the virus from ornamentals is necessary if tomato crops are to be grown in succession or concurrently with ornamentals in the presence of thrips.

ORNAMENTALS

Insects

Chemical control. A rapid and efficient method for the extraction, cleanup, and capillary gas chromatographic (GC) determination of residues of aldicarb, and its major degradation compounds in chrysanthemum leaves, was developed. The leaves are extracted with methanol, and the extracts are cleaned up using a short Nuchar column. Aldicarb, aldicarb sulfoxide, and aldicarb sulfone are determined individually and simultaneously by a capillary GC method, using a nitrogren-phosphorus selective detector, without interference from leaf coextractive.

Diseases

Bacterial leaf spot–stem necrosis of chrysanthemum. The bacterium *Pseudomonas cichorii* continues to be one of the most important chrysanthemum pathogens in Canada since its discovery here in 1983. No registered chemical control measures are available. Resistance to the disease appears to have both morphological and physiological bases, and it has been identified in a survey of 35 varieties of pot mums representing over 15 family lines. This resistance may offer growers some control of the disease. A visual rating system based on infected-leaf standards was developed that enables greater reproducibility of readings by various researchers.

Fungicide resistance in Botrytis cinerea. In 1983 *Botrytis cinerea* from Ontario vineyards and greenhouses was isolated and found to have widespread low-level resistance to iprodione and benomyl, the two primary fungicides used for its control. Furthermore, sensitive and resistance isolates did not vary in pathogenicity. These discoveries are important for the following reasons: resistance to iprodione developed much faster than expected and tank mixes of unrelated fungicides did not signficiantly delay resistance; with resistance to two major groups of fungicides, growers are forced to attain maximum control by other methods, e.g., cultural, and alternative chemical control strategies must be explored before a higher level of resistance develops.

Elm yellows in Ontario. Elm yellows (= phloem necrosis) is caused by mycoplasmalike organisms and is lethal to elm species native to North America. This disease, common in the United States south of the 42nd parallel, was found in the Niagara peninsula in 1984. American, rock, and red elm are important to the Canadian hardwood forests, and are all susceptible to yellows. These elm species have been increasing in numbers and size since the last wave of Dutch elm disease. Also, the only reported vector, which is believed to be the reason for the geographic limits of the disease, is not found in Canada. Another insect vector may be involved, and the limits of yellows may then expand further into Canada.

SMITHFIELD EXPERIMENTAL FARM

Apples

Microprobe monitoring of $CaCl_2$ uptake in apples. An electron microprobe was used to follow the uptake and penetration of Ca and Cl ions into apple fruits that had been immersed in 4% $CaCl_2$ solution under vacuum for 10 min. After 2 days of storage at 20°C, Ca and Cl penetrated approximately halfway into the apple. After 4 wk at 20°C, both ions penetrated all the way to the core flesh, although relatively more Ca than Cl penetrated the inner half of the fruit. Penetration of Ca was slower in fruit held at 2°C than at 20°C, and that of Cl was at least as rapid at 2°C as at 20°C. This in situ analysis technique was also used to determine the elemental composition of specific localized structures, including vascular bundles and lenticels.

The most effective time for treating the apples with $CaCl_2$, from the standpoint of ion penetration and uptake, appeared to be shortly after picking, before cold storage. Sprays applied to the trees in the orchard or treatments applied to the fruit after several months in cold storage were less effective.

Foliar sprays of nitrogen and boron on apples. If orchard fertility levels are adequate, supplying extra N or B by foliar sprays during the tight-cluster to petal-fall periods did not affect fruit set consistently. There are several potential risks, such as softer fruit, advanced maturity, poorer fruit color, and increased preharvest fruit drop associated with the sprays. Either one or two foliar sprays of B did eliminate completely symptoms of B deficiency in fruit in 1983. The established critical level of B at 20 ppm for leaf tissue appears correct.

Synanthedon bark borers in apple orchards. The dogwood borer, *Synanthedon scitula*, is the primary bark borer species attacking apple trees in central Ontario. Burr knots or adventitious root initials were the main points of entry for the borer. The *cis*-, *cis*-isomer of 3,13-octadecadien-1-ol acetate (Z,Z-ODDA) was an effective attractant of the adult stage of the dogwood borer. Two

trunk drench sprays of dimethoate, fenvalerate, permethrin plus oil, endosulfan, parathion, chlorpyrifos, or lindane applied during the period of adult flight activity were effective in controlling this pest.

Performance of McIntosh apple trees infected with virus. Inoculation with Spy decline, chlorotic leaf spot, stem pitting, rubbery wood, and apple stem grooving viruses generally reduced tree size and total fruit yield of two strains of McIntosh on nine Ottawa rootstocks. Not all rootstocks were equally affected. Virus-inoculated trees flowered and fruited slightly ahead of uninoculated trees. Fruit from trees inoculated with virus was generally smaller but had more red color than fruit from uninoculated trees. Virus inoculation also resulted in reduced leaf levels of N, P, K, and Ca in the scion variety.

Herbicides applied to newly planted apple trees. Treatments applied to 1-yr whips of M26 rootstock 1 wk after planting in the nursery gave excellent weed control without injury to the trees. Napropomide plus simazine, alachlor plus oryzalin, and oryzalin plus simazine gave the best weed control and the most growth of the trees.

In 1983, herbicides were applied to a 1st-yr field planting of several apple varieties on M26 rootstock. It was a very dry year, and there was little tree growth. Good weed control without any visible injury to the trees was obtained with a tank mix application of napropomide and simazine or oryzalin plus simazine.

Response of McIntosh to mechanical pruning and growth regulators. McIntosh on MM 106 were planted on a clay loam soil in 1971 and trained to a central leader system at a 5 m × 3 m spacing. A sickle bar mower has been used annually to restrict lateral growth of the trees since 1975. The only hand pruning has consisted of removing low branches and the top of trees using a pruning platform.

The mechanical pruning carried out in the 1st wk of June, followed by an Alar + Ethrel spray in the last week of June, has reduced vegetative growth and promoted fruit bud formation. Total production for the 6 yr, 1979–1984, is 13% higher from the mechanically pruned row than from adjacent normal dormant pruned rows. The pruning time per tonne of Canada Fancy fruit is 0.5 and 3.25 h for the mechanical and dormant hand-pruned rows, respectively.

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Prairie Region
Région des Prairies

W.L. Pelton

J.E. Knipfel

H.C. Korven

A.W. Strachan

Director General *Directeur général*	W.L. Pelton, BSA, MSA, PhD
Program Specialist *Spécialiste en programmes*	J.E. Knipfel, BSA, MSc, PhD
Contracts Specialist *Spécialiste en contrats*	H.C. Korven, BE, MSc
Chief, Administration *Chef de l'administration*	A.W. Strachan

PREFACE

The Prairie Region, with Headquarters in Regina, Sask., consists of ten research stations, three experimental farms, and five substations that serve agriculture throughout the Prairie Provinces. In 1984 the region managed a budget of $55.6 million and employed approximately 265 professionals and 800 support staff.

Resource research emphasises conservation of soil and water, to ensure their productive and efficient use. Rotations were shown to reduce soil degradation problems, but the types of rotations that proved effective depended on the climatic and soil zones involved. In the Brown and Dark Brown soil zones, flex-cropping, where stubble seeding is practical as moisture conditions permit, was proven to be more economically attractive than were fixed rotations or continuous cropping. Application of procedures for conventional, minimum, and zero tillage have demonstrated possible reductions in summerfallow and potential for reduction of soil degradation. Soil and water research has been given high priority; consequently, resources have been reassigned to provide an additional 21 person-years for this program.

Animal production research aims to improve production efficiency. Evaluation of crosses between exotic and British breeds of cattle for feedlot performance and carcass quality continues. Alterations in growth patterns between locations were attributed mainly to different feeding and management practices before and during the test periods. Quality measurements of prime cuts revealed that meat from the progeny of exotic cross dams exceeded meat from that of Hereford–Angus cross dams in percentage of lean tissue per day of age.

The shelf life of frozen bacon was extended from 112 days to 196 days through development of antioxidant combinations for use in the curing process. Bacterial contamination of beef cuts during wholesale handling was observed to be one-and-a-half times as important as was retail sanitation in determining shelf life. Warble infestations of beef cattle under a joint control program between the United States and Canada remained at low levels (2.6–6.6%) following organized insecticidal treatments. On untreated ranch cattle, young stock were infested from 60 to 70% and overall infestations ranged from 20 to 100% of the total cattle populations. Crop cultivars licensed included Challenger Jerusalem artichoke, Sun M 20 sunflower, Maple Isle and Maple Ridge soybeans, Heartland and Norbert barleys, Kyle durum wheat, and Prima fall rye.

Prairie Region managed the contracting-out programs for agricultural engineering research and development (AERD) (mechanization and farm buildings) and wild oat control for the branch, and the station initiatives program for the region. Thirty-three scientists monitored 58 contracts valued at $3.5 million, 45% of which were with industry. The prototype zero-till drill developed by Noble-Versatile under contract has generated such a demand by producers that the contractor was awarded a contract under the program for industry/laboratory projects (PILP) to assist in the development and marketing of production models. Two contracts with Ernest Racz and one to Bechard Sales, both of Ontario, to develop harvesting and drying systems to meet Ontario conditions were instrumental in promoting peanuts as an alternative to tobacco. Because of the completely satisfactory performance of a dehuller for tan oats developed under contract by E.F. Ikomen of Winnipeg, the Canadian Grain Commission no longer opposes the licensing of tan-colored oats on the basis of their similar appearance to heat-damaged white oats. A computer program was developed by Mark Christopher of Regina, which significantly accelerates the summarization of 1228 abstracts for the research report of the Expert Committee on Weeds.

During 1984, Prairie Region Headquarters relocated to Regina from Saskatoon. Dr. E.E. Swierstra was appointed Assistant Director, Lethbridge Research Station. Dr. M.G. Maw was appointed Acting Superintendent, Indian Head Experimental Farm, and Dr. D.W. McAndrew was appointed Officer-in-Charge, Vegreville Substation. Mr. J.J. McConnell, Regional Communications Specialist, retired. Mr. A.W. Strachan was appointed Chief of the Administration Section, Prairie Region Headquarters.

Further information may be obtained by contacting individual research establishments or by addressing inquiries to Prairie Region Headquarters, Research Branch, Agriculture Canada, 401–1955 Smith Street, Regina, Sask. S4P 2N8.

W.L. Pelton
Director General

PRÉFACE

La région des Prairies, dont l'administration centrale est à Régina (Sask.), comporte dix stations de recherches, trois fermes expérimentales et cinq stations satellites qui desservent le secteur agricole des Prairies. En 1984, elle a administré un budget de 55,6 millions de dollars et a disposé d'un effectif d'environ 265 professionnels et 800 employés de soutien.

La recherche sur les ressources naturelles met l'accent sur la conservation des sols et de l'eau, pour une utilisation productive et efficace. Il a été démontré que la rotation culturale peut remédier à la dégradation des sols, mais la succession de plantes à choisir varie selon les zones climatiques et pédologiques. Dans les zones des sols bruns et brun foncé, l'assolement souple avec semis sur chaume, là où les conditions d'humidité le permettent, s'est avéré plus rentable que la rotation fixe des cultures ou que la culture continue. Il a été établi que l'application de méthodes adaptées au travail du sol classique, réduit ou nul offre la possibilité de limiter le recours à la jachère et de freiner la dégradation des sols. On a accordé une priorité élevée aux recherches sur les sols et l'eau; en conséquence, on a réaffecté les ressources afin d'attribuer 21 années-personnes supplémentaires au programme.

Les recherches en production animale ont pour objet d'en accroître l'efficacité. Les travaux d'évaluation des croisements de races exotiques et de races britanniques de bovins à l'égard du rendement à l'engrais et de la qualité de la carcasse se poursuivent. Les écarts entre les courbes de croissance des sujets provenant des divers élevages sont attribuables principalement aux différences dans les régimes alimentaires et la conduite de l'élevage avant et pendant les périodes d'épreuve. Les résultats d'études comparatives des morceaux de choix ont révélé que la viande provenant de la progéniture de mères croisées de race exotique étaient supérieure à celle des sujets issus de mères Hereford-Angus quant au pourcentage de tissu maigre par jour d'âge.

La durée de conservation du bacon congelé a été portée de 112 jours à 196 jours grâce à la mise au point d'une préparation anti-oxygène appliquée à l'étape de la salaison. Il a été démontré que la contamination des morceaux de boeuf par les bactéries au cours des manipulations chez les grossistes contribuent davantage (1 1/2 fois) à réduire leur durée de conservation que les mauvaises pratiques sanitaires à l'étape de la vente au détail. Les traitements insecticides appliqués dans le cadre d'un programme de lutte mené conjointement par les États-Unis et le Canada ont permis de maintenir à de faibles niveaux (2,6 à 6,6 %) l'infestation des bovins de boucherie par les hypodermes. Chez les bovins non traités, de 60 à 70 % des jeunes sujets étaient infestés, et le taux d'infestation global variait de 20 à 100 % de la population totale de l'exploitation. Les cultivars suivants ont été homologués: le topinambour Challenger, le tournesol Sun M 20, les variétés de soja Maple Isle et Maple Ridge, les variétés de seigle Heartland et Norbert, le blé dur Kyle et le seigle d'automne Prima.

La région des Prairies a administré les programmes d'impartition de la Direction générale dans le domaine de la recherche et de développement en génie rural (mécanisation et bâtiments de ferme) et dans celui de la lutte contre la folle avoine, ainsi que les programmes lancés par les stations. Trente-trois chercheurs ont surveillé la réalisation de 58 contrats d'une valeur de 3,5 millions de dollars, dont 45 % ont été conclus avec l'industrie. Le prototype de semoir pour semis direct mis au point à contrat par la Noble-Versatile a suscité une demande telle chez les producteurs qu'on a accordé à l'entrepreneur, dans le cadre du Programme de coopération laboratoire-industrie, un nouveau contrat pour qu'il participe à la conception et à la commercialisation de modèles commerciaux. Deux contrats (avec Ernest Racz et Bechard Sales, tous deux de l'Ontario) dont l'objet était de concevoir des systèmes de récolte et de séchage adaptés aux conditions météorologiques de l'Ontario, ont joué un rôle déterminant dans le choix de l'arachide comme culture de remplacement du tabac. Grâce au fonctionnement sans reproche d'une décortiqueuse pour avoine à grains roux, créée par E.F. Ikomen de Winnipeg dans le cadre de travaux contractuels, la Commission canadienne des grains ne s'oppose plus à l'homologation de l'avoine à grains roux à cause de sa ressemblance avec l'avoine à grains blancs roussie. Mark Christopher de Regina a élaboré un logiciel qui permet de beaucoup accélérer la préparation de 1 228 résumés à inclure dans le rapport de recherche du Comité d'experts sur les mauvaises herbes.

Au cours de 1984, l'administration centrale de la région des Prairies est déménagée de Regina à Saskatoon. E.E. Swierstra a été nommé directeur adjoint de la station de recherches de Lethbridge, M.G. Maw, régisseur intérimaire de la ferme expérimentale d'Indian Head et D.W. McAndrew, préposé à la station satellite de Vegreville. J.J. McConnell, spécialiste régional des communications, a pris sa retraite. A.W.

Strachan a été nommé chef de la Section des services administratifs de l'administration centrale de la région des Prairies.

Pour de plus amples renseignements, veuillez adresser vos demandes aux établissements de recherches ou à l'administration centrale de la région des Prairies, Direction générale de la recherche, Agriculture Canada, 401-1955, rue Smith, Regina (Sask.), S4P 2N8.

W.L. Pelton
Directeur général

Research Station, Brandon, Manitoba

PROFESSIONAL STAFF

Administration

B.H. Sonntag, BSA, MSc, PhD	Director
G.I. Johannson	Administrative Officer
S. Ramsay,[1] BSc(Agr)	Information Officer
R.J. Bomford,[2] BSc, MSc	Systems and programming

Animal Science

G.W. Rahnefeld, BSc, MSc, PhD	Head of Section; Beef cattle breeding
A.G. Castell, BSc, MSc, PhD	Swine nutrition
R.L. Cliplef, BSc, MSc, PhD	Meats physiology
G.W. Dyck, BSA, MSc, PhD	Swine reproductive physiology
R.R. Grandhi,[3] BVSc, MSc, PhD	Swine nutrition
D.L. Grinwich, BSc, MSc, PhD	Swine reproductive physiology
R.M. McKay, BSc, BSA, MSc, PhD	Swine genetics

Plant and Soil Science

L.D. Bailey, BSA, MSc, PhD	Head of Section; Soil–plant relationships
P.N.P. Chow, BSc, MSc, PhD	Herbicides and weed control
R.D. Dryden, BSA, MSc	Agronomy and weed control
C.A. Grant,[4] BSA, MSc	Oilseed agronomy
R.B. Irvine, BSA, PhD	Barley physiology and agronomy
W.N. Migus, BSc, MSc, PhD	Breeding and physiology in corn and sorghum
J.M. Sadler, BSc, MSc, PhD	Soil fertility and plant nutrition
R.G. Simons, BSc, MSc, PhD	Forage agronomy
M.C. Therrien, BSc, PhD	Barley breeding and genetics

[1]Appointed February 1984.
[2]Seconded from Systems and Consulting Directorate, Finance and Administration Branch.
[3]On transfer of work at Virginia Polytechnic Institute, Blacksburg, Va., August 1984 to August 1985.
[4]Graduate student in Branch PhD training program.

INTRODUCTION

The research program at Brandon encompasses beef cattle breeding; swine nutrition, physiology, genetics, and management; breeding, physiology, and management of barley, corn, soybeans, and sorghum; and soil fertility, agronomy, plant nutrition, and weed control in cereal, oilseed, and forage crops. Research programs are designed to solve production problems and to evaluate new opportunities that will enable Canadian farmers, especially those located in the eastern prairie area, to maintain or improve their competitive position in domestic and foreign markets.

Mrs. Sharon Ramsay was appointed the Information Officer in February. Mrs. Ramsay has a BSc(Agr) from Macdonald College, McGill University, and spent the past 3 years in various technical support positions at the Brandon Research Station.

Highlights of research achievements in 1984 include the licensing of Heartland feed barley, the licensing of two Group 000 soybean varieties (Maple Isle and Maple Ridge) selected at Brandon as part of the Ottawa Research Station program, publication of feedlot and carcass quality results from the "Foreign Cattle Breed Evaluation" project, and new recommendations for weed control in corn, sorghum, oilseeds, and forage crops.

This brief report contains highlights of recent findings of our research program. More detailed results can be obtained from our annual Review of Results, from published papers, or by direct contact with research personnel at the Research Station, Research Branch, Agriculture Canada, Box 610, Brandon, Man. R7A 5Z7.

B.H. Sonntag
Director

ANIMAL SCIENCE

Beef cattle

Sex, year, and location effects on post-weaning feedlot traits of three-way cross beef cattle. Substantial ($P < 0.001$) location, year, and sex effects were identified for post-weaning growth traits in a population of 4280 crossbred calves born during a 7-yr period (1972–1978) at Brandon, Man. (B) and Manyberries, Alta. The calves born at Manyberries were transferred to Lacombe, Alta. (L) for the evaluation of post-weaning growth. For one measure of growth rate (feedlot daily gain), the sex difference (M = steers, F = females) averaged 25.6% (M > F). Locations differed by 10.0% (L > B). The maximum year difference was 8.1% (1978 >1973). However, there were substantial interactions ($P < 0.001$) involving location × year, sex × year, and sex × location for most of the traits recorded. These interactions appeared to result from specific and non-uniform year–location–sex differences in feedlot rations or management; with few exceptions, they did not involve changes in ranking of mean values. Location and sex differences in growth patterns during consecutive 28-day periods in the feedlot were attributed to differences in management and feeding practices before and during the test period. The gradual increase in daily energy intake throughout the feeding period at Lacombe inflated variation in the growth patterns and reduced the reliability of growth prediction procedures, compared with a feeding practice at Brandon that attempted to maximize energy inputs at an early age. However, the Lacombe procedure resulted in more rapid growth; thus it appeared to be more appropriate for purposes of challenging the genetic potential for growth rate.

Carcass characteristics of three-way cross progeny from Charolais-, Simmental-, and Limousin-sired F_1 dams versus Hereford × Angus. Carcass characteristics were compared for 3673 steers and heifers born over a 6-yr period (1973–1978) under semi-intensive farm management at Brandon, Man., or in an extensive range management system on short-grass prairie at Manyberries, Alta. Calves weaned at Manyberries were fed and evaluated at Lacombe, Alta. Calves born at Brandon were fed and evaluated at Brandon. The progeny were out of 10 specific F_1 crosses of dams mated to bulls of the Charolais (C), Simmental (S), Limousin (L), and Chianina (Chi) breeds. Dam crosses included the Hereford × Angus (HA) and crosses sired by C, S, and L sires out of H, A, and Shorthorn (N) dams. The progeny from SN dams (Brandon) and the three S-cross dams (Lacombe) had the greatest carcass weight per day of age; the progeny from LH dams (Brandon) and L-cross dams (Lacombe) had the lowest and were equal to progeny from HA dams. The progeny from LN dams (Brandon) and the three L-cross dams (Lacombe) had the highest dressing percentage; the progeny from SH dams

had the lowest and were equal to HA progeny. The progeny from HA dams at Brandon and Lacombe had the most average rib fat. At both locations, the largest rib eye area per 100 kg carcass weight (cm^2/kg) was recorded by progeny from LA dams; the smallest, by progeny from SN and CN dams and they did not differ from HA progeny. The progeny from all exotic-cross dams at both locations recorded higher proportions of round than those from HA dams. The progeny from HA dams (Lacombe) exceeded those from all exotic-cross dams in the proportion of long loin, whereas calves from HA dams (Brandon) exceeded the progeny from CA, CN, and SN dams. With respect to the percentage of lean in the round, the progeny from CN, SH, and SN dams (Brandon) and SN dams (Lacombe) were the lowest and equal to progeny from HA dams. The progeny from HA dams at both locations generally had the lowest percentage of bone in the long loin, with calves from SN dams (Brandon) and CH dams (Lacombe) recording the highest percentage. The progeny from SN and CH dams (Brandon) as well as those from SH and SN dams (Lacombe) recorded the highest percentage of bone in the round, with calves from CA, CN, and LN dams (Brandon) and CA, SA, LH, and LN dams (Lacombe) being the lowest and equal to progeny from HA dams. The progeny from exotic-cross dams at both locations exceeded those from HA dams in the percentage of lean per day of age for the combined trait of long loin and round. The progeny from L-cross dams (Lacombe) had the highest lean-to-bone ratio for the combined trait of long loin and round, with the progeny from HA dams being intermediate and equal to those from other dam crosses. At Brandon, the progeny from LA dams had the highest lean-to-bone ratio; the progeny from CH, CA, CN, SA, and LH dams had the lowest and were equal to the HA progeny. Dam × year, dam × sex, year × sex, and the genetic interaction involving breed of sire and breed of dam were not statistically significant.

Swine

Diet, litter, and sex-type effects on market pig performance. Forty-eight trios (littermate boar, castrate, and gilt) from 31 crossbred (Hampshire × Landrace–Yorkshire) litters were assigned to 36 pens, 12 for each sex-type. The pigs were fed from 22 to 90 kg average liveweight on two different diets: either a standard Record of Performance (ROP) Test Station diet (16.3% protein, 12.83 MJ DE(digestible energy)/kg) or a diet that is used commercially (15.2% protein, 12.59 MJ DE/kg). Growth rates and efficiencies of feed conversion (Gain(G)/Feed (F)) were higher ($P < 0.05$) with the ROP diet. However, diet differences were not reflected ($P > 0.10$) in the carcass measurements. Castrates (C) had the highest ($P < 0.05$) rates of daily intake and growth, but boars (B) were the most efficient ($P < 0.05$) of the sex-types and produced the leanest carcass. Gilts (G) were usually intermediate in live and carcass performance. Differences between sex-types in the proportions of fat and lean in the ham were similar to those observed in the carcass measurements. However, bone content was highest for B hams ($P < 0.05$), and skin content was lower ($P < 0.05$) for G hams compared to hams from B and C pigs. From a subset of 60 pigs (2 trios from 10 litters), significant ($P < 0.05$) "litter" effects were evident for growth and carcass measurements (including bone and skin contents of the ham and nitrogen (N) content of the *l. dorsi*). Two-way interactions (involving diet, litter, and sex-type) were not significant ($P > 0.05$) for any of the criteria examined, but rank correlations for standard growth and backfat suggested that the ranking of the 10 litters was influenced by both diet and sex-type.

Evaluation of lupins in diets for market pigs. A selected line (M.D.A. 75-238) of lupins (*Lupinus albus*) was evaluated by inclusion of the ground seed at levels up to 12% of diets fed ad libitum to 64 crossbred gilts from 25 to 90 kg average liveweight. Dietary levels of lupin meal (LM) exceeding 4%, or prolonged feeding of the 4% LM diet, had an adverse effect on intake and subsequent growth. There was some evidence that lack of maturity of the lupin seeds contributed to the reduction in pig performance. Manganese content of mature and immature seeds was high (1469 and 2039 ppm, respectively). However, the factor responsible for the effects on palatability and utilization of the LM diets was assumed to be an alkaloid component, to which pigs are sensitive.

Piglet growth from birth to weaning. Piglet growth during 35 days of lactation was evaluated for the effects of birth weight, litter size (number born alive), parity, and teat location over the second to fourth parities in Yorkshire (Y) and Yorkshire × Lacombe (YL) sows. Weaning weight was correlated ($P < 0.01$) with birth weight ($R2 = 0.34$ (Y), 0.30 (YL)) and litter size ($R2 = 0.11$ (Y), 0.18 (YL)). The effects of parity and teat location were determined following adjustment for birth weight and litter size. Piglets from third parity sows were heavier ($P < 0.05$) at weaning than piglets from second and fourth parity sows (9.00 ± 0.11 versus 8.58 ± 0.09 and 8.61 ± 0.11 kg, respectively). The effect of teat location on weaning weight was independent of the effect of parity but differed for the two breeds. In Y sows,

piglets suckling the anterior (first) teat were heavier ($P < 0.01$) at weaning than piglets suckling all other teats (9.39 ± 0.13 versus 8.59 ± 0.08 kg). There was no difference in weaning weight for piglets suckling the other (second to last) teats. In YL sows, piglets suckling the first two teats were of similar weight (9.65 ± 0.10 kg) and heavier ($P < 0.01$) than all other piglets. There was a decline in weaning weight from piglets suckling the second teat to those suckling the last two teats (7.95 ± 0.16 kg). These results indicate that teat location has a significant effect on piglet weaning weight, and the difference due to teat location is specific to the breed of dam.

PLANT AND SOIL SCIENCE

Cereal crops

Barley breeding and physiology. Heartland (BT 346), a six-row feed barley, was licensed in 1984. This cultivar combines high yield, lodging resistance, and early maturity with disease resistance that is unique for barley on the prairies. It is the first cultivar to meet or exceed the disease resistance requirements established as a condition for licensing by the National Expert Committee on Grain Diseases, 8 yr before implementation of the new disease criteria in 1992. The exceptional qualities of Heartland are expected to promote its widespread use in the Prairie Provinces. Resistance to true loose smut (*Ustilago nuda*) in barley has been successfully transferred from an Ethiopian biotype (C19973) into hybrid barley lines adapted to the eastern prairie region. Varietal development of these lines is in progress. There is special emphasis on the development of cultivars that are superior to current standards in yield, disease resistance, and other agronomic characteristics. One new feed and three new malting barleys were advanced in 1984 to the Western Cooperative Tests for regional adaptability and agronomic evaluation.

A new technique was developed to evaluate crops for drought tolerance. The technique uses trifluralin to restrict root growth and simulate drought stress on plants, without altering the moisture-flow characteristics of the soil. This method is particularly useful in estimating the ability of different genetic lines to extract water from the soil. Other physiological studies found that the effective xylem radius (EXR) of barley subcrown internodes was affected by seed size, planting depth, and genotype. The EXR is a measure of the total conducting area for water and minerals in the plant, and is calculated from individual xylem vessel radii. As the size of a vessel decreases, the resistance to water flow through it increases. Deep planting and small seed size produced plants with reduced EXR. The two-row genotype *ABEE* had a longer subcrown internode with a smaller EXR than other genotypes at planting depths of 4 cm and 8 cm. The dimension of the largest xylem vessel was a good indicator of EXR. Selection for reduced EXR is being made in advanced barley lines, with the aim of producing plant types that make more efficient use of water and improve on yields in environments where most of the rainfall occurs before grainfilling.

Weed control in cereals. The use of adjuvants with commercial barban (Carbyne) increased its activity and produced better wild oat control, while reducing herbicide rates. Studies using ^{14}C trace techniques found that plant cell penetration by the herbicide was improved. When mixed with an appropriate adjuvant (safener), the herbicidal activity of Hoe 7105 in wheat was also enhanced.

Over a 2-yr period, fall application of granular trifluralin gave effective weed control in wheat and barley, with no adverse effects on the crops. In 1984, the new herbicidal compound AC 222,293 gave excellent control of wild oats in barley; further evaluation is in progress.

Breeding, physiology, and management in corn and sorghum. A new, comprehensive corn breeding project was initiated to develop (*a*) short-season, high-yielding, grain corn hybrids adapted to the 1900–2000 corn heat unit (CHU) regions of the prairies, (*b*) elite inbred lines for release to other breeders, and (*c*) cold-tolerant populations that combine early maturity and rapid growth. Corn inbred lines, populations, and hybrids were advanced through evaluation cycles. However, with only 119 mm of rainfall from May to September (about 45% of normal), the selection pressure was mainly for drought tolerance in the 2500 row inbred nursery. The first killing frost occurred on 26 September, ending the growing season with 2450 CHU. A wet fall (150 mm from September to October) and early snowfall prevented the harvest of 3000 from a total of 5000 evaluation plots. In 1984, a winter nursery (1000 rows) was established in Florida. This is expected to hasten the development of new hybrids.

Grain corn yields were increased by 7% to 20% with the application of elemental sulfur (S) at 60 kg/ha or sulfate–sulfur (SO_4-S) at 30 kg/ha on four sulfur-deficient soils (i.e., the surface 60 cm of soil containing SO_4-S at less than 33 kg/ha). Zinc (Zn) chelate application at 3 kg/ha (elemental Zn) increased corn yields by 5% and 10% on zinc-deficient (< 0.5 ppm DTPA-Zn) and mar-

ginally zinc-deficient (0.5–1.0 ppm DTPA-Zn) soils, respectively. However, the application of zinc chelate decreased yields by 10% on two other marginally zinc-deficient soils. The corn hybrids used in these trials differed in their yield response to applied sulfur and zinc.

In the 2nd and 3rd yr of field studies on sorghum nutrition, applied nitrogen increased the yield of grain and silage sorghums by 40% on a nitrogen-deficient clay soil with adequate moisture stored in the spring. On a dry loamy sand, the lack of precipitation during the growing season negated the response to nitrogen. Further studies with nitrogen, phosphorus, and potassium were abandoned because of lack of moisture.

Weed control in corn and sorghum. Two new recommendations for the control of wild oats in corn were developed. The treatments involve (*a*) postemergence application of flamprop methyl (Matavan and WL43423), and (*b*) preplant harrow incorporation of cyanazine (Bladex), alachlor (Lasso), and triallate (Avadex BW). Both treatments gave excellent control of wild oats, with no adverse effects on the crop.

The first recommendations for chemical control of weeds in sorghum were developed for use in western Canada. The treatments involve (*a*) postemergence application of 2,4-D amine or bromoxynil/MCPA for broadleaf weeds, and (*b*) postemergence application of atrazine for wild oats, green foxtail, and broadleaf weeds. However, alternate herbicides are being evaluated because of risk of injury to other crops following atrazine.

Oilseed crops

Soybean production and management. In 1984, two new Group 000 soybean cultivars were licensed as a result of cooperative research between the Brandon and Ottawa research stations. Maple Ridge and Maple Isle fall within the maturity range of Maple Presto and Maple Amber but are superior to these cultivars in yield, protein composition, and other desirable agronomic characteristics. The regions of adaptability of the new cultivars are similar to those of Maple Presto and Maple Amber. It is anticipated that the total area of soybean production on the prairies will increase as a result of their release.

Four strains of *Rhizobium japonicum* have been identified that are very effective in nodulating and fixing nitrogen with Group 000 soybeans under the cool and short growing season of the prairies.

Rotation studies. Rotation studies on legume and cereal crops indicate that with the use of effective strains of *Rhizobium*, Group 000 soybeans will obtain 60% to 65% of their total nitrogen (N) requirement from symbiotic N fixation, and fababeans will obtain 70% to 80%. Barley grown after soybeans and fababeans yielded 24% to 28% more grain and had 2.7% to 2.9% more protein.

A review of past research on rotations (1893–1982) at Brandon shows the importance of good soil management, tillage system, soil fertility, and weed control for satisfactory returns. Two 4-yr rotation studies with flax, wheat, corn, barley and soybeans, wheat, corn, barley have been carried out under minimum and zero tillage. Better results were obtained with minimum tillage, particularly in corn and soybeans.

Weed control in oilseeds. Research supported the licensing of TF 1189 (Fusilade) for the control of grassy weeds in flax and other broad-leaved crops. Excellent control of wild oats and mustard in triazine-tolerant canola was obtained with a mixture of sethoxydim (Poast) and metribuzin (Sencor, Lexone). AXF 1202 (Sabre) mixed with sethoxydim and RE 36290 provided good control of weeds in flax.

Forage crops

Alfalfa production and management. Research on forage management and fertilizer use showed that it is impractical to cut alfalfa hay four times each year in the eastern prairie region. The time period between cuts is too short for adequate regrowth, and fall weather conditions are often unsuitable for haying. Producers are encouraged to harvest alfalfa three times each year, cutting at the full bud to 5% bloom stage. Under correct management, yield and protein can be improved by 25% and 30%, respectively, over the traditional two-cut system.

Soaking of forage seeds for between 6 and 48 h at either 5°C or 17°C, followed by drying and storage for 1 mo at room temperature, did not improve the germination of eight forage cultivars commonly grown on the prairies. After a further 9-mo storage, seeds that were presoaked for 48 h at 17°C exhibited greatly reduced germination for most species. However, with reduced presoaking, most grass species as well as bird's-foot trefoil showed some increase in germination. On the other hand, the germination of tall fescue, timothy, and alfalfa was reduced by all soaking treatments.

Weed control in forage crops. Results from field research supported the registration of fluazifop-butyl (TF 1169, Fusilade) plus Agral 90 for the control of green foxtail and wild oats in alfalfa. In other experiments, good control of

wild oats and green foxtail was obtained with sethoxydim (Poast) plus Assist Oil; broadleaf weeds were controlled when 2,4-DB was added to the mixture. Diclofop methyl (Hoe Grass) with bromoxynil gave good control of grassy and broadleaf weeds. This mixture is now being formulated and marketed as Hoe-Grass II.

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Research Station, Morden, Manitoba

PROFESSIONAL STAFF

D.K. McBeath, BSA, MSc, PhD	Director
H.G. Brodie	Administrative Officer
M.P. Reimer	Information Officer

Field Crops

G.H. Friesen, BSA, MSc, PhD	Head of Section; Weed science
S.T. Ali-Khan,[1] BSA, MSc, PhD	Breeding of field peas
C.G. Campbell, BSA, MSc, PhD	Breeding of buckwheat
J. Giesbrecht, BSA, MSc, PhD	Breeding of grain corn
G.H. Gubbels, BSA, MSA, PhD	Crop management, physiology
F.A. Kiehn, BSA, MSc	New crops
R.C. Zimmer, BSc, PhD	Diseases of field peas

Horticultural Crops

B.B. Chubey, BSA, MSc, PhD	Head of Section; Vegetable crops
L.M. Collicutt, BSA, MSc	Breeding of ornamentals
C.G. Davidson,[2] BSA, MSc	Breeding of woody ornamentals
G. Mazza, BSA, MSc, PhD	Food science and technology
B.L. Rex,[3] BSA, MSc	Potato management
D.A. Wall, BSA, MSc	Weed control

Oilseed Crops

E.O. Kenaschuk, BSA, MSc, PhD	Head of Section; Breeding of flax
W. Dedio, BSA, MSc, PhD	Breeding of sunflower
J.A. Hoes, BSA, MSA, PhD	Pathology of flax and sunflowers
K.P. Minogue, BSc, MSc, PhD	Pathology of sunflower

Graduate students

R. Green, BSA	Food chemistry
M.M. Shamaila, BSA	Post-harvest technology

VISITING SCIENTIST

S. Akhtar, BSc, MSc Deputy Chief (Planning), Pakistan Agricultural Research Council, Islamabad, Pakistan.	Research management

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[1]Seconded to Canadian International Development Agency Barani Agricultural Research and Development Project, Pakistan, 18 October 1982 to 1 October 1984.
[2]Appointed 1 August 1984; on educational leave.
[3]Appointed 3 January 1984.

INTRODUCTION

The programs of the Morden Research Station are directed toward the development of new cultivars and the improvement of management practices for buckwheat, field corn, field peas, new crops, flax, sunflowers, potatoes, vegetables, and herbaceous and woody ornamentals. This report summarizes some of the results obtained from research conducted during 1984.

Three new cultivars were released or licensed, Challenger Jerusalem artichoke, NorMan flax, and Sun M20 sunflower. A line of semi-leafless peas was selected for possible licensing. A new syndrome of downy mildew on buckwheat was reported, as well as the occurrence of two diseases affecting fenugreek. New understanding was obtained of the genetics of resistance to rust in flax. Several successful herbicide treatments were identified for control of weeds in a wide range of crops.

Further information on any of these research activities, reprints of publications listed in this report, and copies of previous reports may be obtained from the Research Station, Research Branch, Agriculture Canada, P.O. Box 3001, Morden, Man. R0G 1J0.

D.K. McBeath
Director

FIELD CROPS

Buckwheat

Pathology. A possible systemic syndrome of downy mildew on buckwheat seedlings was observed and reported for the first time. Systemic infection, "stunting," was observed on seedlings from six lines of seed harvested in 1980, 1981, and 1982. The mean infection levels for the six lines were 7.3% in 1980, 1.2% in 1981, and 3.2% in 1982.

Weed control. Several herbicides were identified that control wild mustard and other broadleaved weeds in buckwheat. Desmedipham applied postemergence at 0.5 kg/ha, and fluorochloridone applied postemergence at 0.10 kg/ha or preplant, soil-incorporated at 0.5 kg/ha were the most effective.

Field corn

Weed control. Cyanazine plus dicamba was as effective as cyanazine plus Bio-Veg for broad-spectrum weed control in field corn. A new herbicide, AC 222239, selectively controlled wild oats in field corn without serious crop injury.

Field peas

Breeding. A semi-leafless line, MP 919, has been selected for licensing. This line is similar to Century in yield, but it is superior in standing ability and uniformity of maturity and offers many other production advantages. It would be suitable for production in areas with wet fall weather and a high incidence of leaf diseases. Four yellow-seeded lines, MP 916, 934, 940, and 942, have consistently outyielded Century by 9 to 14% in cooperative tests. One of these will be submitted for licensing next year.

Pathology. The potential for seed decay of soils from fields of 11 registered field pea producers was estimated, using the cultivar Century. Germination ranged from 5.0 to 82.5% with a mean emergence of 36.3%. *Pythium* sp., and *Fusarium* sp., were isolated from seed that did not germinate. All isolates of *Pythium* sp., were pathogenic, whereas those of *Fusarium* sp., caused only some discoloration of the seedcoat and epicotyl.

Weed control. Field peas were tolerant to the grass herbicides DPX Y6202 (Dupont), fluazifop-butyl, FOE 3440A (Chemagro), RE 36290 (Chevron), and haloxyfopmethyl. When tank-mixed with metribuzin, all these herbicides controlled annual weed species.

New crops

Jerusalem artichoke. Challenger, a dual-purpose cultivar of Jerusalem artichoke (*Helianthus tuberosus* L.) was released in 1984. This cultivar produces high yields of tan-colored, white-fleshed tubers and a large mass of dense top growth, which normally reaches a height of 210 to 275 cm.

Utilization. The distribution patterns of dry matter, free sugars, total sugars, fructose, and crude protein were determined in tubers of Columbia and Challenger Jerusalem artichoke. The concentration of dry matter decreased progressively from cortex to pith tissues and from stem end to bud end. The decrease in dry matter content between cortex and pith regions was 32 and 36%, and that between stem end and bud end was 3 and 10% for Challenger and Columbia, respectively. On a fresh-weight basis, the total and free-sugar concentrations of the various zones paralleled the dry matter content. On a dry-

weight basis, however, differences between zones were slight. The protein content of the tuber decreased from bud end to stem end and from cortex to pith. The new cultivar, Challenger, had higher total sugars but less free sugars and protein than Columbia.

Weed control. Trifluralin, ethalfluralin, EPTC, chloramben, pendimethalin, and bifenox selectively controlled annual broadleaf weeds in Columbia Jerusalem artichoke. Either 2,4-D or clopyralid alone, or combinations of 2,4-D with dicamba or clopyralid, effectively controlled volunteer Jerusalem artichoke in barley.

Dill weed continued to exhibit tolerance to trifluralin, ethalfluralin, EPTC, chloramben, and sethoxydim.

Fomesafen was the most promising herbicide for the control of broad-leaved weeds in dry beans. This crop was tolerant to all grass-specific herbicides tested. Tank mixtures of metribuzin plus either sethoxydim, haloxyfop-methyl, fluazifop-methyl, or DPX Y6202 provided excellent broad-spectrum weed control in lentils. Preplant, soil-incorporated applications of trifluralin plus metribuzin were more selective than trifluralin plus cyanazine.

Pathology. Two diseases were observed on foliage of fenugreek (*Trigonella foenum-graecum*) in 1983. *Cercospora traversiana* caused serious defoliation and also affected the stems and pods. Powdery mildew was also observed but was not severe.

OILSEED CROPS

Flax

Breeding. The flax cultivar NorMan was licensed. It was developed from the cross [Noralta//(Redwood//(Valuta//))]//Linott. NorMan combines medium-early maturity with high seed yield and high content of fair-quality oil. It is higher yielding than Culbert, Dufferin, and Linott in early seeding, but it yields less than Culbert, Linott, and NorLin in late-seeding. NorMan matures as early as NorLin but is 2 days later than Linott. The cultivar is best suited to the Black and Brown soil zones of the prairies.

Pathology. Postseedling inoculation of flax with the virulent, exotic rust races 22 and 79 showed highly significant differences among cultivars, as well as highly significant variety × race interactions. Mean density of pustules for race 22 ranged from 1% in Culbert to 35 and 62% in Bison and Summit, and for race 79, from a trace in NorLin to 33 and 27% in Bison and Summit. Race 22 generally caused more severe reactions than did race 79. High levels of postseedling resistance to both races 22 and 79 were indicated in the cultivars Culbert, Dufferin, McGregor, Norland, NorLin, NorMan, and Raja.

Studies on the gene base for rust resistance in recently licensed flax cultivars indicated that the resistance of NorLin and NorMan is monogenic and conditioned by the L^6 gene. That of McGregor was bigenic and based on the K^1L^6 combination.

Weed control. Clopyralid was effective for the control of Canada thistle in flax. Haloxyfop-methyl, RE 36290, and DPX Y6202 were effective for season-long control of quack grass. Excellent broad-spectrum weed control resulted from spraying with tank mixtures of bromoxynil, MCPA, plus one of the following grass-specific herbicides: haloxyfop-methyl, DPX Y6202, sethoxydim, or fluazifop-butyl.

Sunflowers

Breeding. An early maturing oilseed sunflower hybrid, Sun M20, has been licensed and is being increased for distribution and sale. Sun M20 is about 2 days earlier and yields 2 to 3% higher than the earlier released hybrid, Morden 12. It has greater self-compatibility than Morden 12 but does not have the same degree of resistance to downy mildew. In addition, five early maturing lines, CM 447, CM 588, CM 590, CM 591, and CM 592, were released to breeders for development of early hybrids.

Management. Diquat was applied to sunflowers to terminate seed development and thereby simulate frost. Early termination of development reduced yields in a late cultivar 42% more than in an early one and greatly reduced oil and protein content and test weight. This demonstrated the importance of choosing an appropriate cultivar, particularly for late seeding or for areas prone to early fall frost.

Weed control. AC 222239 and fluorochloridone applied postemergence resulted in excellent control of wild mustard without injury to sunflowers. The addition of EL 107 to trifluralin applied preplant, soil-incorporated, showed promise for broad-spectrum weed control, including wild mustard.

Soybeans

Weed control. Tank mixtures of grass herbicides plus fomesafen were as effective as tank mixtures of grass herbicides plus bentazon. Tank mixtures of sethoxydim plus bentazon were equal to sequential applications of these herbicides.

HORTICULTURAL CROPS

Ornamentals

Breeding and evaluation. Evaluations of the herbaceous and woody plants in the Morden arboretum and grounds plantings were continued. Thirty-three woody and 229 herbaceous accessions were added to the collection, whereas seven entries were added to the Merit Trial.

The Earl Hornback Award from the North American Lily Society was bestowed on a hybrid lily showing the greatest advance in hybridization. The award-winning lily is a cross between two sections of the genus *Lilium*, the Asiatic and the Trumpet sections, which do not hybridize naturally.

Potatoes

Management. Total yield of tubers and marketable yields of Shepody potatoes decreased with seedpiece spacings decreasing from 46 to 22 cm within the row. Specific gravity decreased with increased spacing at the early harvest; however, no differences were observed at the main-crop harvest. Gross value of the crop decreased with increased spacing within the row, but net crop values were highest at the 38-cm spacing.

Weed control. Several new grass specific herbicides, sethoxydim, haloxyfop-methyl, DPX Y6202, and HOE 33171 provided excellent postemergence control of green foxtail when applied alone or in tank mixtures with metribuzin. R 40244 and bentazon selectively controlled lamb's-quarters and wild mustard.

Vegetables and fruits

Carrots. Among a group of 37 cultivars of processing carrots, Midas Touch and Chantenay Red Cored produced a higher yield of marketable roots than the standard commercial cultivar, Dess Dan, but a slightly lower a:b ratio (the ratio of redness to yellowness as measured on the Hunter Lab color meter). Following processing, the a:b ratio ranged from 1.09 to 1.26, whereas the lowest ratio acceptable to industry is 0.95.

Horseradish. The yield of horseradish roots from both European (Broadfen) and North American (Common) cultivars was more than three times as high after two seasons of growth compared to a single season. A mean yield of 8.4 t/ha was produced after a single season, whereas a yield of 26.2 t/ha was produced after an extra season. A 2-yr growth period may be more economical than a single year in the prairie region.

Garlic. The largest bulbs and the highest total and marketable yields of garlic were obtained when seed was stored at +7°C. Smaller bulbs and lower yields were produced from overwinter storage at +2°C and −1°C.

Weed control. The cabbage cultivar, Houstonn Evergreen, was tolerant to clopyralid having an active ingredient (a.i.) of 0.5 kg/ha, applied post-transplant, and to oxyfluorfen having an a.i. of 1.0 kg/ha, applied pre-transplant. Oxyfluorfen selectively controlled lamb's-quarters and purslane in cabbage.

Utilization and quality. Among 16 cultivars of red beets, betacyanine concentrations ranged from 244.5 mg/100 g fresh weight in the cultivar Detroit Rubidus to 122.7 mg/100 g fresh weight in Firechief, and betaxanthine concentrations ranged from 216.5 mg/100 g fresh weight in Detroit 72 to 67.5 mg/100 g fresh weight in Greentop Bunching. Correlation coefficients were high between betacyanine and betaxanthine but rather weak between pigments and yield, pigments and Hunter color values, and pigments and solids.

Ten hardy apple cultivars, suitable for growing on the Canadian prairies, were evaluated chemically for suitability as raw material for production of apple juice. Total solids ranged from 11.3 to 14.9%, soluble solids from 9.0 to 12.5%, sugar from 7.3 to 10.2%, acid from 0.48 to 0.99%, and phenolics from 0.27 to 0.42%. Because a ratio of 15:16 between sugar and acid is considered to give an optimum balance between sweetness and sourness in juice, Norland and P.F. 51 were the most suitable cultivars for juice production.

Benzaldehyde was the major component of the aroma of saskatoon berries (*Amelanchier alnifolia* Nutt.). Benzaldehyde comprised 26 to 168 mg/kg of fresh berries and 76 to 96% of the essence.

PUBLICATIONS

Research

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Research Station, Morden, Man.

Research Station, Winnipeg, Manitoba

PROFESSIONAL STAFF

T.G. Atkinson, BSA, MSc, PhD	Director
M.D. Hamilton	Administrative Officer

Scientific Support

S. Bishop,[1] BA, MLS	Library Coordinator, Manitoba and Saskatchewan
M. Malyk,[1] BSc, MSc, MLS	Librarian
S.M. Woods, BSc, MSc, PhD	Programmer/Analyst

Cereal Breeding

D. Leisle, BSA, MSc, PhD	Head of Section; Durum wheat breeding
V.M. Bendelow, BSc, MSc, PhD	Cereal chemistry
D. Brown, BSA, MSc, PhD	Oat breeding
A.B. Campbell, BSA, MSc, PhD	Common wheat breeding
E.M. Czarnecki, BSA, MS	Common wheat breeding
P.L. Dyck, BSA, MSc, PhD	Wheat genetics
E.R. Kerber, BSA, MSc, PhD	Wheat cytogenetics
M.I.P. Kovacs, BSc, MSc, PhD	Cereal chemistry
O.M. Lukow, BSc, MSc, PhD	Cereal chemistry
D.R. Metcalfe, BSA, MSc, PhD	Barley breeding and genetics
R.I.H. McKenzie, BSA, MSc, PhD	Oat breeding and genetics
J.S. Noll, BSc, PhD	Physiology

Cereal Diseases

R. Rohringer, DrScAgr	Head of Section; Molecular biology of cereal rusts
J. Chong, BSc, MSc, PhD	Oat crown rust
C.C. Gill, BSc, PhD	Viruses
S.M. Haber, BSc, MSc, PhD	Viruses
D.E. Harder, BSc, MSc, PhD	Oat stem rust
N.K. Howes, BSc, PhD	Molecular biology
W.K. Kim, BSc, MSc, PhD	Molecular biology of cereal rusts
J.W. Martens, BSc, PhD	Wheat stem rust
J.J. Nielsen, DrScAgr	Smuts
D.J. Samborski, BSA, MSc, PhD	Wheat leaf rust
A. Tekauz, BSc, MSc, PhD	Leaf diseases
P.L. Thomas, BSA, MSc, PhD	Microbial genetics, smuts

Stored Products

J.T. Mills,[2] BSc, PhD, DIC	Head of Section; Development and control of storage molds
D. Abramson, BSc, MSc, PhD	Mycotoxicology
P.S. Barker, IA, MSc, PhD	Biology and control of stored grain pests
S.R. Loschiavo, BSc, MSc, PhD	Stored grain insect biology
R.N. Sinha, BSc, PhD	Ecology of granary insects, mites, and fungi
L.B. Smith, BSc, MSA, PhD	Ecology of stored product insects
N.D.G. White, BScAgr, MSc, PhD	Biology and control of stored product insects

Integrated Pest Control

W.J. Turnock,[3] BSA, MSc, PhD	Head of Section; Ecology and population dynamics
G.L. Ayre, BSA, MSA	Insect ecology
R.P. Bodnaryk, BA, MSc, PhD	Biochemistry and toxicology
G.K. Bracken, BSc, MSc, PhD	Physiology and behavior
G.H. Gerber, BSA, PhD	Histology, physiology, and behavior
R.J. Lamb, BSc, MSc, PhD	Systems biology
O.N. Morris, BSc, MSc, PhD	Insect pathology
W. Romanow, BSA, MSc	Insect surveys and control
G.H. Wylie, BA, PhD	Host–parasite relations

Departures

G.F. Atkinson, BSA, MSc, PhD Resigned 17 February 1984	Biometrician
J.L. Buth, BSc, MSc Resigned 17 August 1984	Technical Information Officer
B.M. Hegdekar, BSc, MSc, PhD Resigned 4 May 1984	Diapause and cold hardiness of insects

VISITING SCIENTISTS

D.W. Holden, BSc, PhD Natural Sciences and Engineering Research Council	Molecular biology of cereal rusts
Shang, Hongsheng, MSc	Wheat rusts

Graduate students

C. Aitchison, BSc, MSc	Entomology
A. Baillie, BSA	Oat breeding
R. Butts, BSc, MSc	Entomology
P.P. Claude, BSc	Genetics in wheat
M. Howlader, BSc, MSc	Entomology
W. Legge, BSA	Durum wheat research
Luo Ma, BSc, MSc	Physiology and biochemistry of insects
G. Maiteki, BSc	Entomology
G. Penner, BSA	Cytogenetics in wheat
A. Plourde, BSc	Plant breeding
T. Warkentin, BSA	Oat breeding

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[1]Seconded from Libraries Division, Finance and Administration Branch.
[2]Appointed Head 1 January 1984.
[3]On a transfer of work to Imperial College at Silwood Park, England, August 1983 to August 1984.

INTRODUCTION

Research programs at the Winnipeg Research Station focus on three main areas of responsibility: the development of improved cultivars of cereals specifically adapted to the eastern prairies, research on the protection of stored cereals, oilseeds, and their products, and research on the integrated control of insect pests of field crops. In each of these areas, interdisciplinary teams of scientists are pursuing both mission-oriented and basic research.

Improvements of cereal cultivars, historically the objective of the original Dominion Rust Research Laboratory established in 1925, requires the close collaboration of plant breeders, geneticists, cytogeneticists, plant pathologists, and cereal chemists. In ongoing research to this end, new genes for resistance to wheat stem rust (2), wheat leaf rust (1), and oat stem rust (1) were isolated from distantly related species and incorporated into our breeding programs. The need for such long-term research was emphasized by the appearance of a new virulent race of oat stem rust and by dramatic shifts in virulent biotypes of the net blotch pathogen of barley.

Research on the storage and protection of cereals, oilseeds, and their products is national in scope and involves close cooperation with the Plant Health and Plant Products Directorate, the Canadian Grain Commission, and the grain industry. Particular emphasis is being placed on the ecology of organisms infesting stored grain, chemical and physical measures to control infestations, and the microbiological and environmental factors determining the occurrence of mycotoxins as well as the methodology of their detection. The deregistration of several grain fumigants in 1983 and the detection of insecticide resistance in at least one species of grain-infesting pest is further focusing our attention on improved means of detecting infestations and controlling storage insects with minimal use of chemicals.

Research on the integrated control of field crop insects, particularly those that attack canola and the various "special crops" grown in southern Manitoba, includes the biology and ecology of pest species, the evaluation of biological and chemical control measures, the assessment of economic damage, and the development of management systems. Pest management systems for the bertha armyworm, strawberry cutworm, and for the pea aphid attacking field peas, developed and evaluated over the past several years, were made available for application by growers and provincial extension personnel.

During 1984, Dr. A.B. Campbell and Dr. D.J. Samborski were recognized by the Canadian Agronomy Society and the Canadian Phytopathological Society, respectively, for their many outstanding contributions to the development of improved wheat cultivars and to the understanding and control of cereal rusts. We were saddened by the death of Dr. Fred Kosmolak whose promising career with us as a cereal chemist was cut short in 1982 when he was incapacitated with multiple sclerosis.

The following is a brief summary of research carried out in 1984. Further information or reprints of this report or of the listed publications can be obtained by writing to individual scientists or to the Research Station, Research Branch, Agriculture Canada, 195 Dafoe Road, Winnipeg, Man. R3T 2M9.

T.G. Atkinson
Director

BREEDING, GENETICS, AND CYTOGENETICS

Breeding programs for common wheat, durum wheat, barley, and oats emphasize production of high-yielding cultivars with improved agronomic characteristics and resistance to rusts, smuts, and other cereal diseases. Good quality is a primary objective, involving milling and baking characteristics in common wheat, semolina quality in durum wheat, malting quality in barley, and feeding quality in wheat, oats, and barley.

Barley

The recently released two-rowed cultivar Norbert occupied 8.3% of the total area seeded to barley in Manitoba, which represented 80.6% of the area seeded to two-rowed cultivars. It also occupied 4.3% of the barley area, or 10.0% of the two-row area, in Saskatchewan. Norbert is the first two-rowed cultivar developed with adequate disease resistance for production on the eastern prairies. Results from commercial scale malting trials conducted in 1982 and 1983 indicated Norbert performed satisfactorily, but brewing trials

suggested differences from the standard sufficient to restrict its use as a malting barley.

Other new two-rowed barleys adapted to the eastern prairies continued to be evaluated. A selection that has fast acting enzyme systems, TR212, and which was recently supported for license, was grown at 16 locations across the prairies in 1984 and carload lots currently are in plant-scale malting and brewing trials. Three new selections from the Winnipeg program were tested in the two-rowed Western Cooperative Trials and nine in the Eastern Prairie Trials.

Disease resistance continued to receive increasing attention in 1984. Populations from both the two- and six-rowed programs were screened for resistance to loose smut, spot blotch, scald, and barley yellow dwarf virus. New sources of resistance to stem rust, net blotch, and spot blotch were sought and crosses made to study the genetics of the resistance, and to incorporate resistance into improved lines.

Low polyphenol content, a desirable brewing quality characteristic, has been successfully incorporated into two-rowed barleys. However, a serious problem of very slow filtration has been noted in these lines. High levels of beta-glucan at the end of mashing often cause this problem; in this case, the cause appears to be the failure of the protein, precipitated at the mash saccharification temperature, to coagulate in the absence of polyphenols. Instead, the proteins form aggregates with other insoluble material and impede filtration. The problem is being further investigated.

Common wheat

Several lines in advanced yield tests showed a promising combination of protein content and yield. Generally, high yield tends to be associated with lower protein content. Compared to the check cultivars, these lines were 10–15% higher yielding with comparable protein levels. Their agronomic performance, disease resistance, and general quality characteristics are acceptable; however, they may present a problem with respect to class distinguishable kernel characteristics.

Backcrossing was continued to transfer resistance to loose smut, leaf rust, and sprouting resistance into the "triple M" quality cultivar, HY320. Some of the backcrosses were completed and homozygous lines established.

Stem rust resistance of the synthetic hexaploid Stewart 63/*Aegilops squarrosa*, RL5261, was shown to be due to two dominant genes. These genes are a new and valuable source of resistance, giving excellent resistance to all prevalent races. *A. squarrosa* is also the source of a new, recessive gene for seedling leaf rust resistance that has been transferred to common wheat. Over 180 new accessions of *A. squarrosa* were tested for seedling resistance to stem and leaf rust. Twenty-five were resistant to all races of stem rust, and 130 were resistant to all races of leaf rust. These are being further studied for potential new genes for the common wheat breeding program.

Heritability estimates of post-harvest dormancy were obtained from random lines of crosses RL4137/Timgalen and RL4137/Neepawa. An association between falling number (a measure of post-harvest dormancy) and seedling leaf rust resistance was observed in RL4137/Neepawa but not in RL4137/Timgalen. In the latter cross, the red-seeded lines had a higher falling number than the white lines, whereas the awned lines had a lower falling number than the awnless lines.

The feasibility of using near-infrared analysis for determining the hardness of wheat was examined. The method could be used to supplement quality data supplied to plant breeders.

A study was completed on the biochemical characterization of purified endosperm proteins from germinated wheat. Major effects on milling, rheological, and baking quality of wheat were accounted for by specific changes in the molecular weight distribution of proteins. Endosperm protein composition is one of the key factors in determining the bread-making quality of wheat, and information on its composition is potentially useful to wheat breeding programs.

Durum wheat

In its 1st year of commercial production, the cultivar Medora occupied 6.3% of the Manitoba durum wheat area. It continued to show an advantage in straw strength and yield in regional and Cooperative tests. Two lines in the Cooperative Test for the 2nd year continued to show good yield potential for the Black soil zone. They ranked among the top entries in both years, with average yields of 107.5 and 108% of the best check cultivar.

An excellent source of resistance to new prevalent races of loose smut was identified, and crosses initiated to incorporate this into the newest cultivars. Carbohydrates and proteins were extracted from cooked semolina and flour to determine if any of these components could be used as markers for quality evaluation in the screening program of durum lines. Gelatinization of carbohydrates was significantly different between durum wheat cultivars. Proteins also showed differences but to a lesser extent.

Oats

The popularity of the rust resistant oats Fidler and Dumont continues to increase, with 75% of

the Manitoba hectarage sown to these cultivars. Larger quantities of pedigreed seed of Dumont will be available for sowing in 1985 and this cultivar, because of its large plump kernel, will likely increase in popularity.

A tan-colored oat, OT224, increased for market development by the Canadian Wheat Board, has excellent milling quality. Genetic studies have indicated that low hull content is associated with the tan-colored hull, which appears to be thinner than in white-hulled oats. The tan-colored oat, OT231, has performed very well at the Manitoba test sites in 3 yr of the Western Cooperative Oat Test. It has a yield, percent hull, and percent protein advantage over other entries in the trial.

Work with semidwarf oats is continuing on a reduced scale. Although having very strong straw and reasonable yield, none have consistent high yields equal to Fidler and Dumont.

The development of a good hulless oat with acceptable disease resistance is proceeding. Lines with good resistance were disease tested for the first time in 1984 and some look quite promising.

A newly available stem rust resistance gene, *Pg-16*, is being incorporated into the breeding program. This gene was identified in an Israeli tetraploid *Avena barbata* collection, but the absence of chromosome pairing prevented the easy transfer of this gene into hexaploid *A. sativa*. Attempts to induce a translocation of this gene, using radiation, followed by selection in subsequent generations, resulted in the identification of several *A. sativa* lines carrying *Pg-16*. This gene will be useful in the breeding program, because it confers resistance to all but one of the known races of oat stem rust.

CEREAL DISEASES

Pathology research is multifaceted, and plays an integral part in the breeding of all cereal cultivars. Annual disease surveys are conducted to determine the prevalence of races of rusts and smuts; new genes for resistance to various diseases are identified and transferred to desirable germ plasm; breeders' lines are evaluated for resistance to fungal parasites and viruses; basic studies are conducted on the biology, genetics, histochemistry, and ultrastructure of the pathogens; and long-term research is under way to explain the mechanism of host–parasite interactions and the molecular basis of resistance to cereal rusts.

Rust surveys

In 1984, weather conditions were generally unfavorable for the development of cereal rusts in the field.

Stem rust of wheat. Infections of stem rust developed on Norstar winter wheat and other susceptible wheats in Manitoba by mid-August, but there was no damage to recommended spring cultivars. Fourteen races, including four new ones, were identified but none are a threat to commercial cultivars. Race C53, dominant since 1977, comprised over 90% of the isolates in Ontario and the eastern prairies. Race C4 was most common in Alberta and British Columbia.

Leaf rust of wheat. The identification of races from leaf rust survey samples was carried out with 23 differential lines each with a single gene for resistance. Lines with resistance genes *Lr16*, *Lr19*, *Lr21*, *Lr25*, *Lr26*, *Lr29*, and line T^6 × PI58548 were resistant to all survey samples. None of the isolates from Manitoba and Saskatchewan were virulent on the spring wheat cultivar Columbus nor on adult plants of Benito. Sixty-three virulence combinations were identified, using 16 genes for resistance.

Oat rusts. Oat stem rust and crown rust were first observed in western Canada in mid-July. The incidence remained very low throughout the 1984 oat growing season. In oat stem rust survey samples, race NA27 predominated in western Canada. From eastern Canada, a new race, NA55, which is a variant of the predominant race NA25, was common. This race is virulent on gene *Pg-16*, and could be of significance to the breeding program for oat stem rust resistance. Studies of the virulence of oat crown rust isolates collected in Canada in 1983 were completed. Results indicated that the predominant virulence combinations have not changed greatly within recent years, and none of the combinations represented new races that threaten the combinations of resistance genes currently used in the crown rust resistance breeding program at the Winnipeg Research Station. The new cultivars Fidler and Dumont were resistant to all isolates in 1984.

A preliminary study on the effect of temperature on genes for resistance to oat crown rust showed that, although many oat lines were stable from 16°C to 26°C, lines with *Pc35*, *Pc54*, and *Pc67* became completely susceptible at 26°C, and the line with *Pc68* became less resistant. This demonstrated the importance of temperature control during genetic studies of resistance and in the determination of races of crown rust.

New sources of rust resistance. A derivative from the *Avena sterilis* accession, CAV1084, which may contain unknown oat stem rust resistance genes, has been crossed with the cultivar Makuru, and F_1 seed obtained. Two *A. sterilis* accessions from the Iberian peninsula, IB2433 and IB3056, were crossed with Makuru and F_1 and F_2 progeny have been obtained. These accessions contain resistance to both oat stem rust and oat crown rust. A number of inter-ploidy backcrosses, involving several resistant Iberian wild oat accessions, to the susceptible cultivar Makuru were attempted. Two of these produced BC1F1 seed. Backcrosses were also made to wild hexaploid oats, and BC1F1 seed was obtained. Wild and cultivated lines of oats that exhibited potential stem rust resistance were screened with four stem rust races to evaluate the identity or usefulness of the resistance sources.

Genetics of virulence. Virulence variability was studied in a sexually reproducing population of *P. graminis avenae* in eastern Ontario over a 3-yr period and compared with an asexual population in Manitoba. Twelve virulence combinations were identified in collections from the sexual population versus 11 from the comparable asexual population. Avirulence on resistance conferred by genes *Pg-8*, *Pg-13*, *Pg-16*, and *Pg-a* characterized the Ontario population, whereas avirulence on resistance conferred by genes *Pg-9*, *Pg-13*, *Pg-15*, *Pg-16*, and *Pg-a* predominated in the Manitoba population. The races in the sexual population were more widely virulent (5.5 loci versus 4.0 loci) on average than those of the asexual population.

Molecular biology of cereal rust diseases. Tests were conducted to determine the probable origin of infection-related glycoproteins in intercellular washing fluid from stem rust-infected wheat leaves. Intercellular washing fluid from barley leaves infected with stem rust of wheat contained the same glycoproteins, but that from wheat leaves infected with leaf rust of wheat contained many different glycoproteins compared to the fluid from stem rust-infected wheat leaves. These results suggest that the infection-related glycoproteins are of fungal origin. Intercellular washing fluid is of interest because it may contain products of the genes for avirulence. To detect these, affinity binding or an appropriate bioassay will be required.

Ultrastructure of cereal rusts. A detailed ultracytochemical analysis of stem rust colonies in wheat showed that hyphal walls contain at least four layers, whereas walls of haustorium mother cells consist of up to six layers. The two innermost layers of the haustorium mother cell walls are not continuous with the hyphal walls but form part of the septum. Cytochemical tests, using lectin probes, various stains, protease treatment, and lipid extraction were used to differentiate these layers and this permitted an interpretation regarding their composition.

Cytochemical studies of *P. coronata* indicated that haustoria found in the monokaryotic stage differed greatly in wall composition from haustoria found in the dikaryotic stage (D-haustoria), based on their reactions to lipid solvent or protease treatment. This indicates a difference in specificity in reaction of the fungus to its alternate host. Studies on the nucleate state of the D-haustoria of *P. coronata* indicated that the single nucleus in mature haustorial bodies was larger in size and was more irregular in shape than either of the two nuclei in the young mother cells, suggesting that the nucleus may be in the diploid state. This is unique in that the remainder of the fungal thallus is dikaryotic, and haustoria of *P. graminis tritici*, *P. helianthi*, *Uromyces fabae*, and *Melampsora lini* were dikaryotic.

Smuts

In the 1984 disease survey, 28% of the fields of wheat were infected with loose smut; infection ranged up to 5%, with a mean of 0.09%. Two new races of loose smut of wheat (races T37 and T41) from China were identified. Thirteen field collections from Canada, taken in 1983, yielded known and prevalent races. Smut of barley was found in 75% of fields with an average of 0.6% loose, a trace of false loose, and 0.2% covered smut. No new virulence alleles have been detected since 1972.

Single, recessive genes were shown to cause virulence on each of the differential cultivars Sonop, Kearney, and CT439. The gene for virulence on Sonop (designated as *Utv 5*) is neither identical nor linked with the previously described genes *Utv 1* or *Utv 4*. Whether one of the two last named genes is involved in virulence on Kearney and CT439 is being determined.

The first albino mutant of *Ustilago nuda* found in North America was described. This mutant will be useful as a tool in research on gene linkage where visual identification of strains is important, and in identifying contamination in experiments.

An analysis of progeny of hybrids between the smut species *U. hordei*, *U. nigra*, and *U. aegilopsidis* produced information on the genetic differences between the control of pathogenicity and virulence.

Chemotaxonomic studies. Polypeptides obtained by denaturing spore proteins can be used to assess the taxonomic relationship of related species from which they were extracted. The polypeptide patterns (after two-dimensional isoelectric focusing/polyacrylamide gel electrophoresis) of spores of *Tilletia caries* (rough wall), and *T. caries* intermediate (rough wall with sheath) were identical but differed from that of spores of *T. foetida* (smooth wall).

Differences in polypeptide patterns between *formae speciales* of stem rusts of wheat and oats were much smaller than the differences in polypeptide patterns between leaf rusts of wheat and rye or between any two of the four cereal leaf rusts. Polypeptides from *Puccinia carthami* (safflower rust), *P. jaceae* (diffuse knapweed rust), and *P. centaureae* (black knapweed rust) differed from one another. This helped to clarify the taxonomic positions of these weed rusts, information needed before considering their use for the biological control of diffuse knapweeds.

Foliage mycoses caused by fungi other than rusts. Evaluation of 126 isolates of *Pyrenophora teres* collected in 1982 in western Canada was completed. Significant changes in pathogen biotype distribution compared to 1976 were recognized. The previously predominant biotype is now virtually absent from Manitoba and Saskatchewan. Isolates of *P. teres* with unprecedented virulence on C.I. 5791 barley were identified.

In some barley cultivars, significant differences in leaf stripe reaction occur between inoculated and naturally infected plants. Plots of Summit barley at Glenlea with different levels of leaf stripe showed grain yield losses that averaged 0.3% for each percent leaf stripe. This, and 1983 results, suggest that losses under Manitoba conditions are lower than the 0.6–0.8% reported elsewhere. Field trials on efficacy of foliar protective fungicides to control leaf diseases of Norstar winter wheat were carried out at Portage, McGregor, and Minto, Man. Disease levels were low, and, in contrast to 1983, no significant yield differences occurred with fungicide treatment in any of the tests, although disease levels were reduced.

In response to reports of severe damage from net blotch in plots and fields of Elrose barley in Alberta and Saskatchewan, a study to compare cultivar reaction to the disease at different plant ages was carried out. A revised numerical method of assessing net blotch reaction was used. Some barley cultivars rated susceptible as seedlings, developed resistance as adult plants. Bonanza and Klages barleys showed the greatest degree of adult plant resistance. Testing of wheat lines from the Cooperative Test for reaction to the leaf spot pathogens causing tan spot and *Septoria avenae* blotch was continued. No seedling resistance to tan spot was found. When adult wheat plants were inoculated with *Pyrenophora trichostoma*, leaf spot development on the flag leaf was more restricted in durum than in common wheats. The latter showed a range of symptoms; cultivars Marquis and Sinton were most susceptible.

Viruses. A survey of natural barley yellow dwarf infections was carried out in July and August 1984. Incidence of barley yellow dwarf virus (BYDV) was found to be considerably lower than in recent years; a new isolate of the cherry oat aphid non-specific strain (PAV-type; isolate 8401) of BYDV was obtained and maintained for study.

A filter paper immuno-binding assay was developed for rapid, inexpensive, and sensitive detection of plant viral antigens. A version of this assay can diagnose viral antigen unambiguously, even when the antiserum preparation contains immunoglobulins that react against host components.

Isolate 7601 of the cherry oat aphid non-specific strain of BYDV (PAV-type) was purified and an antiserum was prepared. The corn leaf aphid specific strain (RMV-type; isolate 7404) was purified. Antiserum was not prepared because yield of this refractory virus was still insufficient.

Geminivirus-like particles were detected in oats. The unexpected presence of such particles needs to be understood before a specific antiserum can be prepared with confidence.

STORED PRODUCTS PROTECTION

Research on the biology and control of pests in stored cereals and oilseeds emphasizes the interaction of insects and microorganisms in a dynamic storage environment. The program includes the following: studies of management of grain storage systems; factors that limit long-term storage; survey, prediction, prevention, and control of microflora and mycotoxins in stored cereals and oilseeds; identification and quantification of insects and mites in stored products; influence of attractants and feeding stimuli on insect behavior; and the control of insects and mites by environmental, physical, and chemical means.

Storage ecology

Results of field trials over three consecutive years have demonstrated that forcing outdoor air

into farm storage bins with the aid of small fans is a sound practice to maintain grain quality in western Canada. The trials will continue for at least two more years. The CO_2 values measured remained near the normal, ca. 0.03%, level throughout the storage period. There were no major changes in the level of free fatty acids, which fluctuated from 5.5 to 7.7 mg KOH per 100 g of dry wheat and 7.9 to 12.1 mg KOH per 100 g of dry barley. Both seed germination and microfloral infection levels were similar to those found in sound grain. Arthropod numbers were minimal with only one sample infested by a *Lepinotus* (Psocoptera) and no acarine infestation occurred. Mycotoxins were not found in samples. No adverse affect was observed when pigs were fed on feed derived from the cereals.

A study was initiated to determine moisture/temperature relationships in cereals stored in hopper bins and to create base line data for such bins for advisory work and future research. Temperatures were measured in four hopper-bottomed bins containing wheat and barley on a weekly basis every crop year since 1981, during the September–February period at Argyle, Man. In 1983–1984 mean temperatures recorded at the center of each bin decreased from 30°C to −3°C in two bins containing barley, and from 29°C to 1°C in two bins containing wheat. Carbon dioxide determinations in stored grains are basic to an understanding of the use of CO_2 as a bioindicator in grain bins. The diffusion coefficients (DC) of CO_2 through wheat, oats, corn, and rapeseed were determined in the laboratory, using a specially designed cylindrical diffusion apparatus. The relationship of DC through wheat at −10°C to 30°C was accurately described by a quadratic function (R2 = 0.94). The average DC of CO_2 through stored seeds, listed in order of increasing porosity were as follows: wheat at 13% moisture content (MC), 0.0346; oats at 14.5% MC, 0.0391; corn at 14% MC, 0.0302; and rapeseed at 8% MC, 0.0284.

Mycotoxins

Ochratoxin A, a potent renal mycotoxin, developed during storage of yellow dent feed corn held at 21% initial moisture content under farm granary conditions. This occurred over a storage temperature range of 14° to 34°C. No ochratoxin formed when the corn was stored at 16% initial moisture content. In the 21%-moisture corn, the mycotoxin formed rapidly, and reached a maximum level of 3.6 ppm by 8 wk. Other mycotoxins commonly encountered in storage, namely aflatoxins, citrinin, sterigmatocystin, and penicillic acid, were not found in the corn at either moisture. The causative organism appeared to be a blue-green storage mold, *Penicillium verrucosum* var. *cyclopium* (Westling) Samson, Stolk, & Hadlok, which in past studies was associated with ochratoxin production in stored wheat and barley. In this storage study, the moisture content of the corn appeared to be the most important factor affecting mycotoxin formation. Compared to the 16%-moisture corn, the 21%-moisture sample showed greater changes in the following factors, indicating mold activity: temperature increase, moisture increase, oxygen decrease, carbon dioxide increase, free fatty acid increase, germination loss, and microfloral propagule increase.

Biology

Distribution and abundance studies of insects in farm granaries in the Prairie Provinces are in progress. A survey of empty granaries in Alberta was completed during summer 1984 and data from similar granaries in Manitoba and Saskatchewan are being analyzed. Larvae of scavenger beetles in the families Nitidulidae and Dermestidae were identified and *Omosita colon* (Linnaeus), the most common nitidulid in spoiling stored grain, was confirmed to be present in Manitoba and Saskatchewan granaries.

Experiments with pheromone-baited traps in primary elevator annex bins in 1981, filled granaries in 1982 and 1983, and empty farm granaries in 1983 were completed. Although more rusty grain beetles were collected in baited traps than in unbaited ones, enough beetles were found in unbaited traps to inform the producer of the presence of an infestation.

Development of the American black flour beetle *Tribolium audax* Halstead, occurred between 20°C and 35°C, with optimum development at 30° to 35°C. At 25°C and lower temperatures some larvae entered diapause. Diapause was broken at 30°C in some larvae that were at 22.5°C for 18 wk and 20°C for 13 wk.

Infestation potential of the wheat cultivars Glenlea, Neepawa, Columbus, and RL4137 to two stored product mites, *Acarus siro* Linnaeus and *A. farris* (Gud.) was determined. Glenlea wheat was most susceptible to infestation by both mite species; Columbus wheat was more prone to infestation by *A. siro* than either Neepawa or RL4137 wheat.

Preliminary results indicate that Neepawa was the most susceptible and Columbus the least susceptible of three new wheat cultivars to become infested with the rusty grain beetle, *Cryptolestes ferrugineus* (Stephens). This experiment is now being repeated with an additional wheat cultivar, RL4137, and triticale for confirmation. In a similar experiment with oilseeds, Sundak and Saturn

sunflowers, Candle and Torch canola, and Linott and Dufferin flax, respectively, were the most and least prone to infestation by the red flour beetle, *Tribolium castaneum* (Herbst).

Two lots of severely frost-damaged canola seeds were categorized according to damage type. Seeds from these lots ranged in gross morphology from normal appearance to severely shrivelled, with reduced diameter and white patches over the surface. The white color of these patches was caused by accumulation of starch-like granules in the epidermal layers. Frost-damaged hulls showed a variety of symptoms resulting from arrested development.

Control

Twenty-three strains of *Cryptolestes ferrugineus* were collected in 1982 and 1983 from grain stored on farms in the Canadian Prairie Provinces and in Minnesota, USA. A further 15 strains of *C. ferrugineus* were collected from 68 primary grain elevators near Winnipeg in the summer of 1984. The strains were evaluated for their resistance to malathion. A reliable discriminating dose of malathion having an a.i. of 0.0130 mg/cm^2 with 5 h exposure at 25°C killed all individuals in 38 strains on filter paper. None of the *C. ferrugineus* strains were resistant to malathion, but three strains of *Tribolium castaneum* collected from farms near Winnipeg in 1983 were markedly resistant.

Four strains of *T. castaneum* were exposed to malathion-treated wheat at 0, 2, or 6 ppm insecticide for 12 wk at 32°C. Strains with homozygous, heterozygous, or nonselected resistance factors, and a malathion-susceptible population, were exposed to wheat at these dosages and survival and offspring production observed. Resistance type and insecticide level affected population growth, with the homozygous strain multiplying the most in the presence of malathion. A comparison of tolerances of the eggs of the flour beetles *T. audax* and *T. madens* Charpentier to phosphine (hydrogen phosphide) was carried out. Phosphine concentrations, which reached 0.146 and 0.111 mg/L of phosphine after 3 and 4 days of treatment, respectively, at temperatures of between 16° and 20°C could only kill 50% of the eggs of *T. audax* and 70% of those of *T. madens* by the end of the 4th day. The 7-day mortality was only 90 and 95% for the two species, respectively. Nonchemical procedures for control of pests in stored products were reexamined following the deregistration of several fumigants. The use of diatomaceous earth was effective against the mite *Lepidoglyphus destructor* (Schrank) during exposures of more than 2 wk. At 20°C and 75% R.H., this species survived in an environment that contained almost pure diatomaceous earth for up to 10 days. Dilution of the diatomaceous earth with brewer's yeast prolonged survival of the mites. All mites died when exposures were prolonged to 21 days, regardless of dilution of the diatomaceous earth with yeast. *T. madens* had slightly higher levels of tolerance to diatomaceous earth than *T. audax* had when exposed for comparable amounts of time to the dust. Higher tolerance of *T. madens* was confirmed when both species were placed in mixtures of diatomaceous earth and flour (ratios of 0:100, 25:75, 50:50, and 75:25; w/w; diatomaceous earth-flour).

Preliminary tests on the use of *Bacillus thuringiensis* var. *thuringiensis* Berliner with a beta exotoxin to control stored-product beetles indicated that of the three beetles examined, adults and larvae only of the sawtoothed grain beetle, *Oryzaephilus surinamensis* (Linnaeus), were adversely affected at relatively high dosage rates. The rusty grain beetle, *Cryptolestes ferrugineus*, and the merchant grain beetle, *Oryzaephilus mercator* (Fauvel), were unaffected at the same dosages. The insect growth regulator LY198468 (Fenoxycarb) was found to offer significant control ($P < 0.01$) of *C. ferrugineus* and *Tribolium castaneum* after 24 h exposure of larvae or pupae to wood or steel treated with LY198468 having an a.i. of 0, 0.2, 0.5, 1.0, and 2.0 g/m^2 followed by a 2-wk recovery period. Treated plywood did not affect adult mortality or production of offspring but treated steel surfaces adversely affected production of offspring even at the low a.i. dosage of 0.2/m^2. Exposure to all treated surfaces resulted in high mortality in larvae and pupae and few offspring were produced from adults.

CROP PROTECTION

Research on insect pests of oilseed, field, cereal, and vegetable crops emphasizes aspects of their biology and control leading toward better prediction of infestations, crop protection, and the reduction of pest populations. The program includes the development of pest-monitoring techniques, development and field testing of chemical and biological insecticides, and investigation of methods of reducing pest populations by biological and other nonchemical control methods. These programs are supported by research on sampling techniques, survival, development, phenology, host selection, induction and termination of diapause, overwintering strategies, reproductive biology, and biochemical bases of neurotransmission.

Monitoring and prediction

A method was proposed for monitoring and predicting the abundance of bertha armyworm, *Mamestra configurata* Walker, in Manitoba, using sex attractant traps for male moths. The recommendations, based on 6 yr data over the duration of an outbreak, are for implementation by provincial extension personnel and growers. Catches of less than 20 male moths per trap per season, two traps per location, one location per canola-growing district, indicate that infestations of larvae will not exceed the economic threshold (20 larvae per square metre). If the average catch is from 20 to 100 moths per trap, at least some fields in the district will have damaging larval populations. Catches of more than 100 moths per trap indicate that damaging populations may occur in many fields. When the catch in the district traps shows an increasing trend, individual growers will be advised to purchase and use sex attractant traps in their own fields, because they will then be able to make much more accurate predictions of larval abundance.

Pest management systems

A pest-management system, based on extensive studies of the biology and control of the strawberry cutworm, *Amphipoea interoceanica* (Smith), was made available to extension specialists and growers. Recommended methods of detecting the problem and killing the cutworm have proven to be effective in commercial strawberry production.

Damage assessment

An economic threshold for pea aphid, *Acyrthosiphon pisum* (Harris), in field peas and the optimal time for pesticide application have been determined and a technology transfer publication has been prepared. Growers are advised to assess pea aphid densities at the time of flowering and spray within the week if the proposed economic threshold is exceeded. If growers follow these recommendations, the Manitoba field pea yield should increase by 5 to 10%, with a value of $500 000 to $1 000 000/yr. Field tests on the spread of virus in sprayed and unsprayed legume plots were conducted at Glenlea. In the 4-yr study, no evidence was found to implicate the pea aphid as an important factor in the spread of pea seed-borne mosaic virus.

The cabbage maggot, *Delia radicum* (Linnaeus), was found to have no resistance to the insecticides diazinon and carbofuran. The emergence of adults in the field spanned an 85-day period with a relatively constant frequency of emergence occurring during a 42-day segment in the middle of this period. Captures of adults in water traps showed two distinct generations. Trapping records and subsequent root damage records in three areas indicated that about 5% damage to roots occurs for every adult captured per trap per week.

Studies of the effects of feeding by the sunflower midge, *Contarinia schultzi* Gagne, showed that a regression of yield per head on the fraction of heads over 12 cm diameter and on the fraction of heads cupped due to midge attack accounted for 83.5% of the variation; head size was the more important variable. Mean yield per head for the samples was highly correlated with the respective yields reported by the growers for their fields.

The relationship between pod damage caused by bertha armyworm larvae to yield loss, shelling, and seed grade in canola was studied in field cage studies over two seasons. When larvae fed on canola plants for varying periods of time in field cages, yield loss was linear with respect to feeding time, but the fraction of pods scored "damaged" reached a maximum level of 45% by day 7 of the feeding period, suggesting that pod damage is only a useful measure of yield loss during the first part of an infestation. Shelling, although significantly greater in plots with damaged pods, accounted for only 0.5% of the loss in total yield. Seed grade was lowered by pod feeding as the proportion of green seeds increased with the proportion of damaged pods.

Insecticides

The evaluation of 10 seed dressing and six in-furrow granular insecticides for the control of flea beetles, *Phyllotreta* spp., on canola showed that only three seed dressings were still effective at 15 days after seeding and none were effective after 22 days. Many of the granular insecticides continued to be effective 22 days after seeding and some were still providing 40–60% control 28 days after seeding.

An evaluation of insecticides for the control of the sunflower beetle, *Zygogramma exclamationis* (Fabricius), on sunflowers showed that five of eight candidate insecticides applied as foliar sprays were effective 48 h after application. A synthetic pyrethroid, FCR1272, was the only treatment effective 120 h after application. An evaluation of 10 in-furrow-granular insecticides for control of cabbage maggot, *Delia radicum*, on rutabaga showed that only Counter was effective. Evaluation of insecticides for control of the sugarbeet root maggot, *Tetanops myopaeformis* (Röder), on sugar beets indicated that the registered insecticides (Counter and Temik) and two candidate insecticides (Amaze and Lorsban) were effective and were not phytotoxic.

Testing of various microbial agents for control of the bertha armyworm was continued. Bioassays of commercial *Bacillus thuringiensis* (*B.t.*) (Thuricide and Dipel) and an experimental exotoxin-producing *B.t.*, showed that young larvae (L3 and L4) were highly susceptible to the commercial *B.t.*, but that older instars (L5 to L6) were not. However, the commercial products caused significantly reduced larval and pupal weight gain, pupal emergence, and frass production. The exotoxin had similar effects, and also inhibited molting. Of 22 other strains of *B.t.*, bioassayed against bertha armyworm larvae, seven were more toxic than the commercially used strain (kurstaki).

The synergistic activity of the insecticides chlordimiform, DEF, and piperonyl was studied with the red flour beetle, *Tribolium castaneum* (Herbst). Each chemical was individually of low toxicity. In various combinations, chlordimeform plus DEF, permethrin plus chlordimeform, and permethrin plus DEF showed synergistic interactions. Synergistic effects as high as 25-fold were obtained.

Biological control

Screening of different lines of *Brassica* spp., revealed sufficient inter- and intra-specific variations in the amount of damage from flea beetles to warrant the implementation of a program to increase the host-plant resistance to flea beetles in the breeding of new canola cultivars. The processes that underlie differential susceptibility to damage among cultivars are complex and appear to involve seedling vigor, plant-growth efficiency when plants are damaged, and non-preference by flea beetles.

Of 30 agricultural insect pests tested, 27 were susceptible to the nematodes *Steinernema feltiae* Filipjer and *Heterorhabditis bacteriophora* Poinar. Several pest species were judged good candidates for biocontrol by nematodes. Three strains of the nematode *S. feltiae* and two species of *Heterorhabditis* were bioassayed for dosage mortality responses against larvae of the bertha armyworm, redbacked cutworm, *Euxoa ochrogaster* (Guenée), and greater wax moth, *Galleria mellonella* (Linnaeus). *S. feltiae* was more effective against these three species than the *Heterorhabditis* spp. Laboratory tests on the survival of the nematodes in moist soil outside their hosts showed no mortality at 10° or 22°C for 6 mo. High temperature (36°C) killed most of the nematodes.

Biology

The suitability of four indigenous species of Cruciferae, *Descurainia pinnata* (Walt.) Britt., *D. richardsonii* (Sweet) O.E. Schultz, *Lepidium densiflorum* Schrad. and *Rorippa palustris* (L.) Besser), and one introduced species, *Erysimum cheiranthoides* L., were tested in the laboratory as host plants for the larvae of the red turnip beetle, *Entomoscelis americana* Brown. *R. palustris* was a suitable food plant, but *D. pinnata*, *D. richardsonii*, *E. cheiranthoides*, and *L. densiflorum* were only marginally suitable. All five of these species should be controlled by growers in areas where the red turnip beetle is a pest of canola and mustard crops. The hatching of red turnip beetle eggs is well adapted to the temperatures of early spring. An average of 90% of the fertile eggs hatched from 10° to 36.5°C, indicating a broad optimal temperature range for hatching. The threshold and upper limit were near 5° and 38.5°C. The hatching rate was calculated for each temperature and curves were fitted to this data, using eight developmental rate curves from the literature.

An asymmetrical normal function accurately described the effect of constant temperature on the hatching rate. These findings could assist entomologists and extension specialists in predicting outbreaks of the red turnip beetle. Also, criteria for selecting mathematical models for describing insect development were established; thus contributing to the theory concerning the evolution of developmental rates in insects.

An efficient and low-cost preparative technique for isolating the calcium-binding protein, calmodulin, in a pure form was devised in collaboration with the Department of Agricultural Chemistry in Japan. The method reduces the preparation time from more than 2 wk to less than 2 days while doubling the yield over conventional methods. Several calmodulins were isolated from different insects and their structures were compared with mammalian calmodulins. The insect calmodulins contain no epsilon trimethyllysine but are active in stimulating adenylate cyclase, calcium-dependent phosphodiesterase, and calcium uptake in insecticide-treated synaptosomes.

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Research Station, Melfort, Saskatchewan

PROFESSIONAL STAFF

S.E. Beacom, BSc, MSc, PhD	Director
G.M. Bell	Administrative Officer
D.J. Ewanus, BSc	Farm Manager

Forage Production and Utilization

J.A. Robertson, BSc, MSc, PhD	Program Leader; Beef cow–calf nutrition, pasture management
S.E. Beacom, BSc, MSc, PhD	Utilization of harvested forages
S. Bittman, BSc, MSc	Forage crop production
E.Z. Jan, BSc, MSc, PhD	Forage harvesting systems
D.H. McCartney, BSc, MSc	Beef cow–calf and pasture management systems
Z. Mir, BSc, MSc, PhD	Ruminant nutrition, forage utilization
J. Waddington,[1] BSc, MSc, PhD	Forage ecology and weed control

Cereal, Oilseed, and Special Crop Production

K.E. Bowren, BSA	Program Leader; crop production
W.F. Nuttall, BSc, MSc, PhD	Soil fertility, crop nutrition
L. Townley-Smith,[2] BSc, MSc	Cereal, oilseed agronomy
A.T. Wright, BSA, MSc	Crop evaluation and agronomy

VISITING SCIENTIST

Priya Srihara, BSc, MSc, PhD Natural Sciences and Engineering Research Council visiting fellow	Ruminant nutrition

[1]Transferred to Swift Current, September 1984.
[2]PhD trainee.

INTRODUCTION

The Melfort Research Station staff is involved in three main areas of research. One involves developing more efficient forage production, harvesting, storage, and utilization systems to provide beef cattle producers with a wider range of feeding alternatives and to encourage greater use of forage crops in rotations in the interests of better soil management. Another involves the evaluation of a wide range of cereal, oilseed, pulse, and perennial forage crops under various management and environmental conditions to develop optimum production systems over the long term. The third involves developing efficient beef cow–calf systems in the aspen parkbelt, including pasture management and renovation. The last named program is carried out in cooperation with the Saskatchewan Department of Agriculture and the Horned Cattle Purchases Act Advisory Committee and was formally extended for another 5-yr period in late 1984. The results of our crops research is directly applicable to an immediate area that includes 10% of Canada's improved agricultural soils, whereas the forage systems and beef cattle management/nutrition research is applicable to a much larger area.

In 1984, Mr. Lawrence Townley-Smith was added to the station staff as a PhD trainee in the area of crop agronomy.

Brief summaries of some of our work are presented in this report. For further information readers may obtain a copy of our *Research Highlights 1984* by writing to the Research Station, Research Branch, Agriculture Canada, Box 1240, Melfort, Sask. S0E 1A0. (Telephone: (306)752-2776)

S.E. Beacom
Director

FORAGE PRODUCTION AND UTILIZATION

Forage crops

Response to fertilizers. Response to the application of fertilizers to alfalfa (*Medicago media*) grown on three soil types was determined over several years. In the spring of each year, N at rates of 10, 45, and 67 kg/ha^{-1} was applied in combination with S at rates of 9, 22, and 45 kg/ha^{-1}. These treatments included an application of P at the rate of 20 kg/ha^{-1}. A control with no fertilizer yielded an average of 2.15 t/ha^{-1} per cut (Wv 1, *Typic Cryoboralf*). An additional treatment (22 N, 0 P, 26 S kgha^{-1}) yielded 3.01 t/ha^{-1} per cut (average 10 cuts), the most economical treatment on Wv 1. Response to S fertilizer was significant on Wv 1, but only significant in one year on Whitefox fine sandy loam (Wf fsl, *Typic Cryoboralf*), which was initially slightly lower in 0.01 M $CaCl_2$ soluble-S [18.4 versus 16.5 Sμg (4 g)$^{-1}$ soil]. Contrary to expectation, a yield response of 0.76 t/ha^{-1} of herbage to the application of S at 45 kg/ha^{-1} was obtained in 2 yr on Melfort silty clay (M sic, *Typic Cryoboroll*), a soil initially containing a very high amount of SO_4-S [46μg (4 g)$^{-1}$ soil]. Results indicated that soils need to be tested every 4–5 yr to provide a basis for adjusting sulfur fertilizer rates. Regression analyses revealed that N significantly increased yield per cut on Wv 1 and Wf fsl soils, and that S increased yield on Wv 1, averaged over 5 yr.

Forage harvesting

Energy requirements. Most forage harvesting equipment is driven from the tractor power take-off. For most efficient energy use, it is important that the load on the power take-off be steady and that it match the power delivered. "Underloading" is the main cause of energy wastage.

Field cutting of the forage crops is more efficient when using a swather with a 3.7 m cut than when using a mower conditioner with a 2.7 m cut (3.58 L/ha versus 6.83 L/ha). The wider cut and the shorter turning time both contributed to improved efficiency. Also, the wider cut forms heavier windrows, which make the subsequent operation more efficient.

Forage yield per unit of land has a marked effect on the efficiency of baling. Where the yield was only 0.56 t/ha, fuel consumption for the large round and standard square baler was 5.03 and 4.89 L/t, respectively. With a crop yield of 5.5 t/ha, fuel consumption dropped to 0.99 L/t and 1.00 L/t, respectively, and baling rate was markedly increased. The soft-core round baler consumed almost twice as much fuel as did the hard-core round baler due to its high peak power requirement. To improve efficiency, heavier windrows should be formed by using a wider swather or a double windrow attachment.

Grinding alfalfa bales at 11% moisture required 7 L/t for screen sizes of 7, 10, and 13 mm. At a moisture content of 18%, the fuel consumption increased to 19 L/t with the 7-mm screen, 14 L/t

with the 10-mm screen, and 10 L/t with the 13-mm screen. The work rate decreased rapidly with the increase of moisture content and the decrease in screen size (at 11% moisture 3.5, 4.6, and 4.8 t/h, and at 18% moisture 1.2, 2.2, and 2.4 t/h for the 7-, 10-, and 13-mm screens, respectively). Filling the tower silo with an electric motor-driven forage blower cost 15 cents per tonne compared to 54 cents per tonne when a tractor-powered blower was used (electricity at 6 cents per kilowatt hour and diesel fuel at 40 cents per litre).

Roughland pasture management

A long-term experiment has been under way to evaluate methods of renovating roughland seeded pastures, using rotational grazing, fertilizer, and a reseeding program. In 1984, the original non-fertilized control pasture produced 1355 kg/ha dry matter (DM) yields. Pastures that had been reseeded to brome and alfalfa in 1979 and 1981 and fertilized with 90 kg N and 45 kg P prior to the 1984 grazing season produced 3637 kg/ha, whereas similar fertilized original stands produced 3499 kg/ha. For the period 1974–1984, control pastures produced 1179 kg/ha, pastures fertilized prior to grazing averaged 2889 kg/ha, and pastures fertilized the previous year produced 1627 kg/ha. Reseeded, fertilized, and rotationally grazed fields supported 119.8 cow days per hectare (1978–1983); original stand, fertilized, and rotationally grazed fields supported 108.4 cow days per hectare; and non-fertilized continuously grazed fields provided 63.7 cow days per hectare. Cost of fertilizing was offset by the value of the increased calf gain per hectare, 56 kg/ha versus 89.1 kg/ha.

Remote sensing of pastures

A remote sensing system has been developed and tested in cooperation with Intera Technologies of Calgary, Alta., and a technology transfer has been initiated with Sask. Lands Branch and the Prairie Farm Rehabilitation Administration (PFRA), for pasture management in Saskatchewan. It has been shown that 1:5000-scale 35-mm color infrared (CIR) aerial photo transparencies provided accurate biomass estimates to within 10 gm/0.25m^2, using texture of the photo as the basis of interpretation. Landsat data, enhanced as classified DICS-format showed differences in pasture types, biomass levels, and the location of shrubs, trees, water, and cultural features. It was concluded that a multistage remote sensing system consisting of a combination of large and medium scale CIR photographs and digital Landsat data would provide information required for various pasture management applications in Manitoba, Saskatchewan, and Alberta, and could be applied relatively consistently from year to year and from region to region.

Beef cattle

Rations and implants for finishing steers. Finishing beef steers fed barley silage plus increasing levels of grain (averaging 3.6 kg/day per head), ground crested wheat grass hay (valued at $55/t), ground alfalfa hay (valued at $66/t), and rolled barley ($132/t) plus 10% ground cereal straw-based rations, gained 1.16, 1.46, 1.42, and 1.61 kg/day per head at feed conversion ratios of 9.49, 9.53, 10.49, and 7.68, respectively (90% DM basis for all rations), to return $7.54, $59.83, $42.51 and $46.95 per head, respectively, to labor. The percentage of steers grading A_1 or A_2 was 89, 85, 89, and 100, respectively, whereas dressing percentages averaged 53.1, 51.9, 52.5, and 54.3, respectively. The surprising finding was the good economic performance of the steers fed the crested wheat grass (crude protein (CP) 14.0%) ration compared to those fed the alfalfa (CP 16.7%) ration.

On the basis of rate of gain, adjusted for dressing percentages, Compudose and Ralgro plus Synovex S were superior to Ralgro for grain-fed steers, Ralgro and Compudose were superior to Ralgro plus Synovex S for silage-fed steers, and Ralgro plus Synovex S was superior to the other two implant treatments both for alfalfa- and for crested wheat grass-fed steers. When averaged across all rations, all three implant treatments produced highly satisfactory increases in rate of gain ranging from 13 to 23% over unimplanted steers.

Supplementing the grain-containing ration with 2% acidulated fatty acids (AFA) improved animal performance in some respects, but it reduced dressing percentages and was uneconomical. Adding 2% AFA to the ground hay-based rations improved animal performance, dressing percentage, and increased return by an average of $20 per head.

Ammoniated barley straw in diets for wintering mature, pregnant beef cows. Ammoniation of barley straw (3.5% NH_3 by weight–dry matter basis) increased the crude protein content and in vitro digestible organic matter of Bonanza straw from 5.2 and 36.5% to 7.4 and 41.9%, and of Klages straw from 3.9 and 29.3% to 6.1 and 35.1%, respectively. Both control and treated straws were fed ad libitum throughout the winter feeding period to groups of mature, pregnant beef cows. Each group was fed the same quantity of barley (DM at 1.8 kg/day per head), whereas the diet of animals fed the control straw was further

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supplemented with 0.33 kg DM canola meal and brome–alfalfa hay, the quantity of which was adjusted so as to maintain the rate of gain of the controls the same as that of those fed ammoniated straw. To meet the additional requirements of lactation, the amount of barley fed to both groups was increased by 2.4 kg DM per head over a 5-wk period beginning just prior to the onset of the calving season in late March. The performance of cows fed the two diets, as determined by change in body weight, calving percentage, average birth weight, and percent conception were similar for cows fed each of the diets. The intake of Klages barley straw, despite a lower crude protein and in vitro digestibility than that of Bonanza, was 30–40% higher than Bonanza in both the untreated and ammoniated forms. Costing of both diets indicated average daily feed costs per cow were similar, which suggests that ammoniation may be a practical method of improving nutritive quality of straws, particularly at times when the price of alternative feeds such as hay and grain is high.

CEREAL, OILSEED, AND SPECIAL CROP PRODUCTION

Methods of seeding stubble

In a 4-yr study on the effects of tillage and seeding on crop yields (co-op with Sask. Farm-Lab Program) minimum tillage for seedbed preparation followed by seeding with double disc press drill yielded on average 2464 kg/ha. Direct seeding with a narrow (1 cm) shovel hoe press drill produced average yields of 2460 kg/ha, both significantly higher (L.S.D., 52 kg/ha, $P = 0.05$) than when an air seeder was used on a prepared seedbed (2156 kg/ha) or in direct zero till seeding (2362 kg/ha). Crop sequence was wheat, wheat, barley, and canola. Seeding with a triple disc zero till press or with a discer seeder and packer yielded 2322 and 2365 kg/ha, respectively. Stands seeded with the press drill were more uniform and matured a few days earlier than those seeded with the air seeder, particularly with canola.

Earlier swathing of barley

A 5-yr study at Melfort has shown that Bonanza barley can be swathed at about 40% kernel moisture content (KMC) without loss in yield or quality. Windrowing at this stage permits harvesting 5 to 10 days earlier than normal (KMC 20%, or less) and reduces losses due to seed shattering. Windrowing is widely practiced in western Canada as a means of reducing ripening time and shattering prior to combining.

Control of quack grass in canola

Good control of quack grass (*Agropyron repens* L.) with two new herbicides, DPX 6202 (0.2 to 0.5 kg/ha) and DOW 453 (0.5 kg/ha) was obtained at Melfort. This weed is a serious problem in extended rotations in northern Saskatchewan and its control will be of considerable benefit to producers.

Wheat midge

Yield losses attributed to the orange blossom midge in northeastern Saskatchewan approached $30 million in 1983. Wheat yields in some fields were as low as 150 kg/ha. In the intested area, both plowing and burning of wheat stubble were widely practiced as producers attempted to control this insect.

A study that was undertaken to determine the effect of various trash management practices on midge emergence, demonstrated that proper management of wheat stubble is effective in reducing midge populations in subsequent crops. Zero-tillage of wheat stubble resulted in earlier and greatest emergence. Less than one-half as many adult midges emerged when stubble was burned just prior to seeding. Differences among other tillage treatments, which included three combinations of fall and spring cultivation and plowing, were not significant, and numbers emerging were intermediate between those found in zero-tilled and burned plots.

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Research Station, Regina, Saskatchewan

PROFESSIONAL STAFF

J. Dueck, BSA, MSc, PhD	Director
L.E. Hurry,[1]	Administrative Officer

Support Staff

Vacant	Information Officer
R.K. Schmidt,[2]	Systems Manager/Analyst
R.F. Wise	Computer Programmer
S.P. Yanosik,[3]	Library Technician

Biological Control of Weeds

P. Harris, BSF, DIC, PhD	Head of Section; Entomology
M.G. Maw, BSc, MSc	Entomology
K. Mortensen, BSc, PhD	Plant pathology
D.P. Peschken, BSA, MSc, DrSciAgr	Entomology

Weed Ecology and Physiology

G.I. McIntyre, BSc, PhD	Head of Section; Physiology, water relations, dormancy
G.G. Bowes, BSA, MSc, PhD	Range weeds
A.I. Hsiao,[4] BSc, MSc, PhD	Physiology, dormancy
L. Hume, BSc, PhD	Crop losses, ecology
J.H. Hunter, BSA, PhD	Control—annual crops
A.G. Thomas, BSc, MSc, PhD	Surveys, ecology

Environmental Chemistry of Herbicides

R.Grover, BSc, PhD	Head of Section; Availability, mobility
A.J. Cessna,[5] BA, PhD	Residues, plants
A.E. Smith, BSc, PhD, DSc, FCIC	Residues, metabolism, soil

Seed Increase

G.R. Boughton, BSA, MSc	Head of Section

Experimental Farm, Indian Head, Sask.

Vacant	Superintendent
D.A. Derksen,[6] BSA	Agronomy

Departures

C.J. Bubar, BSA, MSc Resigned December 1984	Information Officer
D.I. Gourlay Transferred to Prairie Region Headquarters, Regina, July 1984	Administrative Officer

S.F. Forsyth, BSc, MSc, PhD	Biological control of weeds
W.A. Quick, BA, BEd, MA, PhD	Weed physiology

Graduate student

R. Boyle-Makowski, BSc(Hon), MSc	Biological control of weeds

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[1]Appointed 5 November 1984.
[2]Appointed 3 February 1984.
[3]Seconded from Libraries Division, Finance and Administration Branch, June 1983.
[4]On transfer of work from September 1984.
[5]On transfer of work from April 1984.
[6]Appointed 4 September 1984.

INTRODUCTION

The program of the Regina Research Station focuses on the biology and control of weeds in cultivated crops and pastures. The extensive use of herbicides in prairie agriculture has created a demand for scientific information on efficacy, crop tolerance, persistence in soil, and movement away from the intended target. In recent years, our program has also examined exposure hazards to herbicide sprayer operators and successfully developed means to minimize hazards in handling herbicides. New technology is being developed for the use of plant pathogens and insects for the control of weed species as an alternative to control with herbicides. In addition to the weed research program, the station has responsibility for increase of seed of new crop varieties developed by Agriculture Canada for distribution to the seed industry and for a winter plant breeding nursery in California. Cereal, oilseed, forage, and pulse crops are evaluated for adaptability to southeastern Saskatchewan. The station also participates in the South Saskatchewan Wheat Breeding Program. Agronomic experiments develop new information for soil and crop management.

The operations of the Indian Head Experimental Farm are being revitalized through a series of internal changes. The Seed Increase Unit is being relocated to the Experimental Farm from Regina. A new seed plant was constructed, the equipment was moved, and land preparation was completed. Staff relocation will take place in time to be fully operational at the new site by the 1985 growing season. Both agronomist positions were vacant for most of the year and research activities were temporarily curtailed. With the hiring of one agronomist, new program initiatives have begun. Program plans will be completed after recruiting a second agronomist.

Departures from the station include C.J. Bubar, Information Officer, who resigned to pursue a PhD program in weed science, and D.I. Gourlay, Administrative Officer, who transferred to Prairie Region Headquarters. Dr. A.J. Cessna spent most of the year studying pesticide chemistry with Ciba-Geigy in Switzerland, and Dr. A.I. Hsiao went to the University of California, Riverside, Calif., to study physiology of herbicide activity.

Enquiries for detailed information on research activities may be directed to the Research Station, Agriculture Canada, 5000 Wascana Parkway, P.O. Box 440, Regina, Sask. S4P 3A2.

J. Dueck
Director

BIOLOGICAL CONTROL

Canada thistle

Although previous releases of the stem gall fly *Urophora cardui* (L.), which had been brought over from Europe, failed to become established on Canada thistle in western Canada, colonies have been thriving in eastern Canada. Therefore, it was decided to release larvae from eastern Canadian stock in Saskatchewan and compare the survival rate to those from Europe. Results from 1983 and 1984 showed that 81% of larvae from New Brunswick survived the winter in Saskatchewan versus about 30% of the larvae of European stock. Thus, it would appear that the New Brunswick population has become considerably more winter hardy than the insects from the original collection site in Europe and new releases are being made in western Canada with this stock. This behavior is similar to other biological control agents that have become abundant after a period of adaptation. In addition, observations in New Brunswick confirmed earlier speculation that wind-protected areas favor the development of this insect, so efforts are being made to carefully select more suitable release sites.

Narrow-leaved hawk's-beard

A project was undertaken in 1982 to determine the suitability of narrow-leaved hawk's-beard, a weed prevalent in alfalfa and mixed forage crop in western Canada, for biological control. The 2-yr study showed that the weed does not occur in sufficient numbers in alfalfa fields used for dehydration in Saskatchewan to cause significant losses in yield. With respect to forage quality, it was found that protein content of narrow-leaved hawk's-beard was an average 1.5 times lower than alfalfa. In order to reduce the protein content of the alfalfa pellets below the minimum required level, the proportion of the weed in the pellets would have to exceed 25%, which seems highly unlikely. Based on the surveys conducted, even where the weed was found to occur at very high densities such as in some alfalfa hay fields and in fields of creeping red fescue grown for seed, crop yields were not affected. In the bromegrass–alfalfa pastures surveyed, it was found that young

plants of narrow-leaved hawk's beard were eaten readily by cattle, so that over all densities were low. Therefore, it is apparent that narrow-leaved hawk's-beard derives its reputation as a weed because it is showy, conspicuous, and a good colonizer. It is too weak a competitor to cause significant forage losses and its presence has little influence on the quality of forage or alfalfa pellets. Thus, narrow-leaved hawk's-beard is not a suitable target for biological control.

Knapweed

Diffuse and spotted knapweed currently infest 83 000 ha of rangeland in British Columbia and grass yields on this land have declined by up to 90%. The weeds threaten 10 million hectares in western Canada and have been spreading at about 9% a year despite a vigorous chemical containment program. Approximately 95% seed reduction is needed for a decline in the weed population. The establishment of the seed head gall flies *Urophora affinis* Frfld., and *U. quadrifasciata* (Meig.) have gone a long way toward achieving this threshold, with reductions commonly over 90%.

It was previously shown that the rosette-root moths *Agapeta zoegana* (L.) and *Pelochrista medullana* Stgr., were specific to a few species of knapweed, and between 100 and 200 larvae of each species were bred from the few moths obtained from eastern Europe. These were released in September 1983 by transferring them to knapweed rosettes growing at Summerland, B.C. All the rosettes at the *P. meddulana* release site were destroyed by voles during winter and it became necessary to establish a new release site. Approximately one-half of the *A. zoegana* larvae survived the winter. The establishment of these moths will be a valuable addition to knapweed control, since each larva destroys the roots of several small or one medium-sized rosette in the spring. Additional insects are being screened as potential biocontrol agents.

The knapweed rust *Puccinia jaceae* Otth., inflicts considerable damage to knapweed in Europe, but under laboratory conditions it was found to also affect the seedling stage of safflower. The adult safflower plants were completely resistent. Field tests with this rust will be conducted in France in 1985–1986 to determine if the rust affects and does any damage to safflower under natural conditions. Data from these tests are critical for deciding whether the rust can be safely approved for release in Canada, and they may set a precedent for the future screening of biocontrol agents that have a marginal ability to attack non-target plants.

Leafy spurge

The root-feeding beetles *Aphthona flava* Guill., and *A. cyparissiae* Koch., have been established at two locations in Saskatchewan. The populations are at a low level but the insects have been proven capable of surviving the winter and should contribute to the control of leafy spurge on wet sites. Releases of the spurge hawkmoth *Hyles euphorbiae* (L.) from new European stock were made this summer at Maxim and Caronport, Sask. A project was initiated to examine the effect of several biological control agents on the stress physiology of leafy spurge. A survey and study of the native pathogens occurring on leafy spurge was completed and it was determined that none of the isolated disease organisms, of which *Alternaria* spp., were the most prevalent, have potential for biological control.

WEED ECOLOGY AND PHYSIOLOGY

Crop loss survey

The losses from potential production due to weeds in crops grown in the four western provinces were estimated by surveying research and extension personnel as part of a joint project of the Weed Science Society of America. Of the total loss of $723 million, approximately 85% occurred in field crops, 3% in vegetable crops, 1% in fruit and nut crops, less than 1% in forage and seed crops, and 10% in hay crops. Approximately 48% of the total loss occurred in Saskatchewan, 29% in Alberta, 17% in Manitoba, and 6% in British Columbia. This information is of benefit to producers in developing economical integrated weed management strategies, extension agencies in identifying crops for which the greatest gains would be expected, and research groups in developing a cost-benefit rationale for enhancing food production through weed research.

Weed–wheat competition

Field studies were conducted to determine the importance of including crop density in studies on weed–wheat competition and making estimates of crop losses due to weeds. In the farm fields and research plots examined, it was found that wheat density taken in adjacent 1 m^2 quadrats varied by an average of 25 plants, regardless of the seeding implement used. Densities could vary by over 100 crop plants in individual comparisons. Yield, dry weight, and tillering of individual plants decreased with increasing wheat

density. It was shown that the current methods for studying weed competition in small grain crops, using yield comparisons of weed-free and weedy quadrats to estimate crop loss, can be highly distorted if crop density is not taken into account. A more accurate procedure has been developed, using multiple regression that relates both crop and weed abundance to crop loss. The equation used is $y = ax_1 + bx_2 + c$. Where y = crop loss; a and b are partial regression coefficients; X_1 is a crop density measure; X_2 is a weed abundance measure; and c is a constant.

Control of persian darnel in wheat

The effect of custom-mixed fertilizer (N at 56 kg/ha, P at 36 kg/ha) on the control of persian darnel with diclofop methyl was examined under field conditions. When the fertilizer alone was applied, both the number of culms and the dry weight of the persian darnel decreased by 30 and 20%, respectively, whereas the wheat showed a significant increase in number of culms and dry weight as well as a 54% increase in grain yield. The addition of fertilizer was more beneficial to the wheat than to the weed and the resulting increase in crop competition caused decreases in the growth of the persian darnel. This beneficial effect of the fertilizer on the crop was also evident when the diclofop methyl was applied to control the persian darnel. In the presence of the fertilizer, the herbicide resulted in a 30% increase in wheat yield over plots treated with the herbicide alone. These results support the hypothesis that in order to get good control of persian darnel with diclofop methyl, it is necessary to have good growing conditions to increase crop competitiveness.

Herbicide efficacy and crop tolerance data

Research data from the four western provinces on performance of herbicides related to efficacy and crop tolerance is collated on an annual basis into a three-volume report. To facilitate accumulation and handling of the data involving approximately 1200 abstracts annually, a computer program was developed in 1976. Changes in technology, including vastly lower rates for some herbicides, differences in tolerance among cultivars within a crop, and different formulations of the same herbicide required modifications to the program in 1984. The computerized input of data will lead to development of an effective data comparison system. The volume of data included in the report is increasing by 10% annually.

Seed dormancy in wild oats

Under controlled conditions a study was conducted of changes in the water content of the embryo of the wild oat seed in relation to the onset of dormancy and the experimental induction of germination. Dormancy developed rapidly between 18 and 22 days after anthesis. At the beginning of this period the water content of the embryo was 119% of dry weight and decreased to 13% at maturity. During 10 days of imbibition by the mature caryopsis the embryo water content increased to a constant maximum level of 121% but the seed remained dormant. When the dormant embryo was then excised from the fully imbibed caryopsis and placed on wet filter paper, its water content increased by approximately 10% within 30 min. After a further 18 h, germination occurred. It is felt that this response was not due to leaching of germination inhibitors from the embryo, because germination also occurred when the embryos were kept in a saturated atmosphere but not in contact with water. These results are consistent with the hypothesis that seed dormancy in wild oats is due to factors that prevent the uptake of imbibed water by the embryo in the amount required for germination.

Glyphosate translocation in quack grass

A series of experiments were conducted under controlled conditions to investigate the effect of both root and shoot applications of nitrogen on the uptake and translocation of ^{14}C-labeled glyphosate in quack grass. When the nitrogen supply to the roots was increased from 5 to 210 ppm for 21 days prior to the application of glyphosate, herbicide uptake was increased by 65% and there was 60% increase in the amount translocated out of the treated leaf. A similar increase in the nitrogen supply for only 4 h prior to herbicide application has the opposite effect, immobilizing the herbicide in the treated leaf and causing a 40% reduction in the amount translocated to other parts of the plant. However, the application of nitrogen to the leaves of low nitrogen plants promoted glyphosate translocation, significantly increasing the amount that was moved out of the treated leaf and resulting in a 35% increase in the amount in the roots. Further studies are required to evaluate the use of foliar nitrogen application as a means of increasing the effectiveness of glyphosate for quack grass control.

ENVIRONMENTAL CHEMISTRY OF HERBICIDES

Exposure levels during herbicide application

A program was initiated in 1980, in collaboration with the University of Saskatchewan College

of Medicine and Health and Welfare Canada, to obtain reliable and quantitive data on exposure of applicators to herbicides during spraying. After initially studying the exposure of an aerial application crew to 2,4-D iso-octyl ester in 1980, the program was continued in 1981 and 1982 to examine the exposure of farmers applying the amine salt of 2,4-D with tractor-pulled groundrigs. As with the aerial applicators, it was found that the percent dermal exposure of the groundrig operators was greater than 99, whereas less than 1% of the total exposure could be attributed to inhalation. The area of the body that was most exposed were the hands, which had more than 90% of the dermal exposure. The indirect method of measuring exposure, using the amount of 2,4-D excreted in the urine, indicated that less than 1% of the total exposure was actually absorbed. In the regions of the body covered by two layers of cotton clothing consisting of a shirt, a pair of pants, and coveralls, dermal exposure was reduced by 80 to 90%. Consequently, it is felt that by using gauntlet-type rubber gloves during all spray tank filling, container rinsing and sprayer maintenance operations, and by wearing two layers of cotton protective clothing, dermal exposure to herbicides by groundrig operators can be effectively minimized.

Herbicide persistence in soils

The degradation of ring-labeled [^{14}C] chlorsulfuron was studied under field conditions at a rate of 660 g/ha in small sandy loam plots. Soil was sampled to a depth of 10 cm, and after 45 wk between 5 and 10% of the applied radioactivity was recovered as chlorsulfuron, whereas approximately 15% of the initial activity was in the form of the degradation product 2-chlorobenzenesulfonamide. After 95 wk about 2% of the original radioactivity remained as chlorsulfuron in the soil, and approximately 20% remained as sulfonamide. The persistence of formulated chlorsulfuron, at a rate of 40 g/ha was also investigated under field conditions, using small plots at two locations for three successive years. Using a corn root bioassay procedure, it was observed that between 4 and 16% of the herbicide applied during May was recoverable from the top 10-cm soil layers the following May.

Herbicide residues in sainfoin

An analytical method was developed to determine residues of trifluralin in sainfoin wet forage and hay with limits of detection of 10 and 50 µg/kg, respectively. Sainfoin plots were treated with 1.12 kg/ha preplant incorporated applications of trifluralin at Agriculture Canada research facilities located at Lethbridge, Melfort, and Indian Head. Replicate samples of sainfoin wet forage were collected at the various locations when the sainfoin was in early to full bloom. Additional samples were collected of sainfoin that was left in the field to cure into hay at the Melfort Research Station only. Analysis showed that trifluralin residues in both the forage and hay samples were less than either of the respective limits of detection.

SEED INCREASE AND DISTRIBUTION

In 1984, Agriculture Canada released to the SeCan Association 300 kg of Kyle durum wheat, 178 kg of NorMan flax, and 400 kg of Prima fall rye. In addition, 6525 kg of HY320 wheat and 375 kg of TR212 barley were released to the Canadian Wheat Board and 650 kg of Heartland barley were released to SeCan for further increase under contract. Breeder seed of 55 varieties was distributed to 693 growers.

Breeding material from 24 plant breeders across Canada underwent multiplication and selection at a winter nursery in southern California.

A program for verification of varietal purity of certified seed was again carried out in cooperation with the Plant Health and Plant Products Directorate and the Canadian Seed Growers Association. The general level of contamination in the 3331 samples grown was very low, with no variety displaying any consistent high levels of off-types.

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Research Station, Saskatoon, Saskatchewan

PROFESSIONAL STAFF

J.R. Hay, BSA, MS, PhD, FWSSA	Director
R.K. Downey, OC, BSA, MSc, PhD, FAIC, FRSC	Assistant Director; Oilseed breeding—canola
R.J. Peters	Administrative Officer

Scientific Support

R.E. Howarth, BSA, MSc, PhD	Head of Section; Legume bloat—biochemistry
M.J. Bentham, BSc, MSc	Computer Systems Manager
D.M. Kichuk,[1] BFA, BA, MLS	Librarian
C.E. Lynn, BSA	Information Officer
H.K. Milne	Computer Systems Programmer
D.T. Spurr, BSc, MSc, PhD	Statistician
R.E. Underwood	Photographer

Oilseeds

R.K. Downey, OC, BSA, MSc, PhD, FAIC, FRSC	Head of Section; Oilseed breeding—canola
A.P. Arthur, BSc, MSc, PhD	Oilseed crop insects
L. Burgess, BSc, MSc, PhD	Oilseed crop insects
K.L. Falk,[2] BSc, MSc	Oilseed breeding—canola
D.S. Hutcheson,[3] BA, BSA, PhD	Oilseed breeding—canola
D.I. McGregor, BSc, MSc, PhD	Physiology of *Brassica* spp.
G.A. Petrie, BA, MA, PhD	Oilseed crop diseases
G.F.W. Rakow, BSA, PhD	Oilseed breeding—canola
G.Séguin-Swartz, BSc, PhD	Cytogenetics of *Brassica* spp.
H. Ukrainetz, BSA	Soil fertility
P.R. Verma, BSc, MSc, PhD	Oilseed crop diseases
D.L. Woods,[4] BPharm, MPhil, PhD	Oilseed breeding—mustard, sunflowers

Cereals

H. Harding, BSc, PhD	Head of Section; Cereal
K.L. Bailey,[5] BSc, MSc	Cereal root diseases
W.L. Crowle, BSA, MSc	Cereals and crop management
L.J. Duczek, BSA, MSc, PhD	Cereal root diseases
R.D. Tinline,[6] BA, MSc, PhD, FCSPP	Cereal root diseases

Forage Crops

B.P. Goplen, BSA, MSc, PhD	Head of Section; Legume breeding
C.H. Craig, BA	Forage crop insects
B.D. Gossen,[7] BSc, PhD	Forage and low-temperature diseases
M.Y. Gruber,[8] BSc, MSc	Plant biotechnology
R.E. Howarth, BSA, MSc, PhD	Legume bloat—biochemistry
R.P. Knowles, BSA, MSc, PhD, FAIC	Grass breeding
G.L. Lees, BSc, PhD	Legume bloat—plant physiology

Insect Pest Management

J.F. Doane, BSA, MS, PhD	Head of Section; Insects—ecology and behavior
G.R.F. Davis, BSc, MSc, PhD	Insects—physiology and nutrition
R.H. Elliott, BA, PhD	Insecticides
M.A. Erlandson,[9] BSc, MSc, PhD	Insect virology
A.B. Ewen, BA, MA, PhD, FRES	Insects—ecology and pathology
R.J. Ford, BSA, MSc, PhD	Engineering
F.J.H. Fredeen, BSA, MSc	Black flies
C.F. Hinks, BSc, ARCS, DIC, PhD	Insects—toxicology
M.K. Mukerji, BSc, MSc, PhD	Insects—management
O.O. Olfert, BSc, BSA, MSc, PhD	Insects—ecology
N.D. Westcott, BSc, PhD	Pesticide—chemistry

Scott Experimental Farm

K.J. Kirkland, BSA, MSc	Superintendent; Weeds and crop management
S.A. Brandt, BSA, MSc	Agronomy

Departure

J.D. Smith, BSc, MSc Retired 11 February 1984	Forage and low-temperature diseases

VISITING SCIENTISTS

S.N. Acharya, MSc, PhD Canola Council of Canada visiting fellow, 1980–1981; research associate, 1982–1984	Plant pathology
L. Ge Canadian International Development Research Centre visiting research scientist, 1984–1985	Plant breeding
W. Manzoor, BSA Canadian International Development Research Centre training fellow, May to September 1984	Plant breeding
J.P. Raney, BSc, PhD Canola Council of Canada research associate, 1984–1985	Plant biochemistry
M.J. Swartz, BSc, MSc Natural Sciences and Engineering Research Council visiting fellow, 1984-1985	Plant biochemistry
A. Tereffe, DIP Canadian International Development Research Centre training fellow, August 1984 to February 1985	Plant breeding

Graduate students

G. Alemaw, BSA	Plant breeding
D. Dostaler, BSc, MSc	Plant pathology
H.K. Love, BSA, MSc	Plant breeding
H.-M. Kao, BSA, MSc	Plant biotechnology
Y. Semeane, BSc	Oilseed pathology
R.-C. Yang, BSc	Plant pathology

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[1]Seconded from Libraries Division, Finance and Administration Branch.
[2]On educational leave, University of Saskatchewan, from 1 May 1984.
[3]Appointed 3 July 1984.
[4]On a Canadian International Development Agency (CIDA) assignment to Njoro, Kenya, from 4 July 1983 to 31 August 1984.
[5]On educational leave, University of Saskatchewan, from 1 April 1984.
[6]On transfer of work to Queensland Wheat Research Institute, Toowoomba, Australia, August 1983 to 5 March 1984.
[7]Appointed 13 August 1984.
[8]On educational leave, University of Guelph, from 21 September 1984.
[9]Appointed 3 July 1984.

INTRODUCTION

This report covers the results of work completed in 1984 at the Saskatoon Research Station and the Scott Experimental Farm, 160 km west of Saskatoon. Four research programs are conducted. The oilseed, forage crops, and cereal programs include research on breeding, agronomy, and control of diseases, weeds, and insects. We have the major responsibility in the Research Branch for research on rapeseed/canola and mustard. We, along with the Lethbridge and Kamloops research stations, are an integral part of the Branch's research program on development of bloat-safe alfalfa. We have a major responsibility for the development of forage grasses for the northern prairies. The cereal program is mainly concerned with reducing losses from root rot in wheat and barley, and with the breeding of utility wheats. The integrated pest management program deals with the development of control systems for problem insects (i.e., grasshoppers, wireworms, wheat midges, black flies) that are not specifically restricted to any one commodity. A major objective in the program is the minimization of our dependence on insecticides for the control of these pests.

Three new scientists joined the staff, Dr. D.S. Hutcheson, a plant breeder, will be working on development of hybrid canola. Dr. M.A. Erlandson, an insect pathologist, strengthens the Integrated Pest Management program with his research on use of pathogens for the control of insects. Dr. B.D. Gossen, a plant pathologist, will carry on the research on cold temperature diseases of forage crops and winter cereals previously conducted by J.D. Smith, who retired after 19 yr service.

Dr. R.D. Tinline returned from a transfer of work in Australia, doing research on common root rot. Dr. D.L. Woods returned from a foreign assignment in Kenya.

Previous reports and reprints of publications can be obtained from the Saskatoon Research Station, Research Branch, Agriculture Canada, 107 Science Crescent, Saskatoon, Sask. S7N 0X2.

J.R. Hay
Director

OILSEEDS

Rapeseed/canola

Breeding and utilization. The two most recent canola cultivars developed at Saskatoon, Tobin, licensed in 1980, and Westar, licensed in 1982, occupied over 76% of the area seeded to canola in western Canada in 1984. Nearly all of this area was sown with Certified seed, probably the highest use of Certified seed ever achieved by any major crop in western Canada. It is estimated that the additional production obtained by farmers using Tobin and Westar amounted to approximately $100 million in 1984.

Biotechnology. The high androgenic *Brassica campestris* L. genotype (*7B3-10*) produced an extremely high number of embryos from cultured anthers. Selfed progeny plants of *7B3-10* varied in their ability to produce embryos. Results from F_1 hybrids from selfed progeny plants of *7B3-10* × cultivar Tobin, a low androgenic genotype, showed that the high embryogenic characteristic is transferable. Its inheritance, however, appears to be complex.

Insects. The composition of the flea beetle population attacking canola crops in the Saskatchewan parklands was monitored with attractant traps for 2 yr. The striped flea beetle, *Phyllotreta striolata* (Fabricius), was the most abundant species in the canola-growing areas near the northern forest, whereas the crucifer flea beetle, *P. cruciferae* (Goeze), was by far the most abundant species elsewhere in the parklands. Similar trends in the relative numbers of the two pest species were evident in sweep net catches in canola crops.

Adult flea beetles hibernating in a parkland grove of trees were samples for three consecutive winters to determine their numbers and distribution within the grove and assess the value of winter sampling for monitoring flea beetle populations. In one winter, the combined population of hibernating adult crucifer and striped flea beetles in the grove was estimated to be in excess of two million beetles per hectare. Both species showed a clumped or aggregated rather than an even distribution in the grove. The great variation in numbers of beetles obtained in different sampling sites indicated that too many samples would be required for winter sampling in groves to be a practical method of estimating flea beetle abundance over large canola-growing areas.

Diseases. Preemergence and postemergence damping-off, root rot, and basal stem, or foot rot, are important seedling diseases of canola in western Canada. They are manifestations of a complex of organisms, with *Rhizoctonia solani* Kuhn

being the main component. Seedling diseases are frequently a major factor contributing to poor canola stands, particularly in the Peace River region. Recent studies at Saskatoon of soil samples from Beaverlodge and Fairview, Alta, indicated that in that region *R. solani* is also the main organism causing a serious mature plant disease called brown girdling root rot. However, *Pythium ultimum*, *P. polymastum*, and *Fusarium* spp., plus a number of other fungi, were also present.

In comparing anastomosis groupings (AG) of *R. solani* found in Saskatchewan and Peace River soils, all five isolates from the Alberta soils belonged to the AG2-1 group, which is known to be a specialized root pathogen of many crucifers. However, only half of the isolates from Saskatchewan soils belonged to this group. The other half belonged to the AG4 group, which is not restricted to crucifers and is less virulent on them.

A reliable growthroom technique has been developed for screening canola for resistance to damping-off and seedling root rot caused by *Rhizoctonia*.

Mustard

Breeding and utilization. Tame mustard, *Brassica juncea* L., is now grown by Canadian producers as a condiment crop on approximately 80 000 ha in western Canada. Recent discoveries show that it could be developed as an important oilseed crop. It is more drought resistant and higher yielding than the current rapeseed cultivars. Low erucic acid has now been bred into some strains of this crop. However, the high level of the glucosinolates, which gives rise to allyl isothiocyanate in the meal remaining after oil extraction, prevents the use of the meal as a livestock feed. A procedure has been developed at the Saskatoon Research Station to overcome this problem. Treating mustard meal with ammonia during extraction reduces the glucosinolate content to a level similar to that of canola meal. Feeding trials with swine have shown that the ammoniated mustard meal is comparable to various canola and soybean meal combinations in terms of animal growth, feed efficiency, and utilization. Supplemental lysine will be required if ammoniated mustard meal is used as the major protein source for growing pigs.

Before glucosinolates were reduced in rapeseed meal, utilization in poultry diets was restricted due to the presence of the glucosinolates, a high fiber level, and the resulting low metabolizable energy content. The low glucosinolate canola cultivars produced a more nutritious and less goitrogenic meal but one which is still high in fiber due to the high proportion of hull in relation to the size of the seed. However, feeding broiler chickens canola meal, in which the fiber content was reduced to about half of its normal content by screening, did not improve broiler performance. As part of the same study, heating the meal to 100°C during the desolventization stage of oil extraction produced higher feed intake and faster growth. The results suggest that canola seed may be improved for broiler feeding if the myrosinase enzyme responsible for the breakdown of glucosinolates to toxic products is inactivated by heating at the later desolventizing stage when this is not accomplished during the initial cooking stage of processing.

Sunflowers

Insects. The sunflower stem weevil, *Cylindrocopturus adspersus* Leconte, was found in 1984 for the first time in southeastern Saskatchewan. Sampling at eight locations near Alida, Carievale, Bienfait, Weyburn, and Trossachs, Sask., yielded stems infested with populations varying from a low of 1.0 to a high of 14.8 larvae per stem. Although relatively high populations were present in some sampled fields, plant lodging was not serious. However, reports of up to 10% of plants lodging in a few fields in the area were received. Accurate estimates of the number of larvae per stem required to cause economic damage are not available. The wide distribution suggests that the sunflower weevil was present in Saskatchewan prior to 1984.

FORAGES

Legumes

Pasture bloat. Pasture bloat has traditionally been associated with legume forages. However, bloat can also occur when winter wheat fields are grazed in the southern Great Plains region of the United States. A comparison of these two circumstances provided an opportunity to understand better the causes and occurrence of pasture bloat. In each instance, bloat is associated with immature herbage. Both immature alfalfa and wheat are low in fiber and high in total nitrogen and soluble nitrogen. Both herbages are susceptible to rapid digestion by rumen microorganisms. However, they differ markedly in mineral composition, particularly the higher potassium, and lower calcium and magnesium in wheat herbage, compared to alfalfa herbage. Comparison of rumen contents, prior to and during bloating, confirmed that both are a frothy type of bloat. The

program to breed a bloat-safe alfalfa cultivar continued and progressed into the third generation of selection for slower initial rate of digestion, using a modified in vivo nylon bag digestion technique. Practical recommendations for the management of legumes in pastures and for the control of legume bloat were published.

Tannins in bird's-foot trefoil. The herbage of bird's-foot trefoil contains secondary plant metabolites called "condensed tannins." These compounds are of special interest to the forage plant breeder, because these tannins appear to prevent pasture bloat in cattle by acting as protein precipitants, thus precluding the formation of rumen foams. Tannin-containing legume species, such as bird's-foot trefoil, sainfoin, and crown vetch, are considered to be bloat-safe. An inheritance study showed that the presence of tannins in bird's-foot trefoil is controlled by a single dominant gene. This simple genetic control of the tannin trait is of interest to the forage breeder, because it may be possible to transfer this gene and the bloat-safe characteristic to the true clovers and alfalfa, using advanced biotechnology techniques.

Low-temperature grass diseases. Several low-temperature tolerant fungi that have potential as biological control agents have recently been identified in an international cooperative project. These fungi produce a diffusible chemical that is antagonistic to various snow mold pathogens. One of these fungi, *Acremonium boreale* Smith & Davidson, first described from the Canadian prairies and Norway, was shown to be the anamorph (a sexual stage) of *Nectria tuberculariformis* (Rehm ex Saccardo) Winter. *N. tuberculariformis* is widely distributed in Central Europe, Canada, and the northwestern United States. A new species, *N. muelleri* Samuels, Rogerson, Rossman, & Smith, was found in Central Europe in association with *N. tuberculariformis*. A *Nectriella* species was isolated from a grass in Switzerland. Also, *Hyponectria sceptri* (Karsten) Comb. Nov., which is widely distributed in Iran, Switzerland, and the United States, was redescribed.

CEREALS

Wheat and barley

Common root rot. The ranking of barley lines and cultivars for common root rot reaction was similar at Beaverlodge and Fort Vermilion, Alta., and at Saskatoon and Scott, Sask., despite differences in the level of disease among locations. Correlation between disease rating and grain yield loss was inconsistent, but in general increased disease intensity was associated with increased yield loss. Yield loss was related to reduced numbers of heads but not to a reduction in thousand kernel weight. Of the two pathogens that cause common root rot, *Fusarium culmorum* (W.G.Sm.) Sacc., was isolated in equal or greater frequency than *Cochliobolus sativus* (Ito & Kurib.) Drechsl. ex Dastur from subcrown internodes at Beaverlodge, whereas *C. sativus* was isolated most frequently at the other locations. In greenhouse tests, isolates of both fungi were highly variable in pathogenicity, but there were no consistent differences between isolates taken from the Peace River area and those from the southern prairies. Thus, it should be possible to make selections for common root rot resistance in barley at any of these locations in western Canada.

Weed research. The influence of clopyralid on control of wild oats (*Avena fatua* L.), when mixed in the spray tank with four herbicides, was tested at Scott, Sask., and Lacombe, Alta. Clopyralid mixed with diclofop methyl and applied at the two-leaf stage and with difenzoquat applied at the four-leaf stage did not affect control of wild oats. When barban and flamprop methyl were mixed with clopyralid and applied at the two- and four-leaf stage of wild oats, respectively, a reduction in control was observed.

The efficacy of diclofop methyl, flamprop methyl, difenzoquat, and barban on wild oats in wheat was tested in the field at Scott and Lacombe from 1978 to 1982. The four herbicides were applied at recommended rates and growth stages. Diclofop methyl consistently caused the greatest reduction in wild oat culms and plant weights, and resulted in the largest wheat yield increases. Diclofop methyl, flamprop methyl, and difenzoquat produced yield increases over the untreated control.

INTEGRATED PEST MANAGEMENT

Grasshoppers

Control. Quantitative studies of the effect of *Nosema locustae* as a control agent against grasshopper populations revealed that about 50% of the predominant species were infected between 4 and 5 wk after application of 2.5–5.0 × 109 spores of *N. locustae* per hectare. Ninety-five to 100% of the grasshoppers were infected between 9 and 12 wk after application. This increase in infection in time is probably due to healthy grasshoppers consuming infected cadavers.

Over all, the treated populations of the migratory grasshopper (*Melanoplus sanguinipes* (Fabricius)) and Packard grasshopper (*Melanoplus packardii* Scudder) were reduced by about 20%, 4 wk after spore application and by about 60%, 8 wk later. The population of the clear-winged grasshopper (*Camnula pellucida* (Scudder)) was reduced over all by only 28%, 12 wk after spore application, indicating that this species is less vulnerable to *N. locustae* infection.

N. locustae reduced the fecundity of grasshoppers that survived. In two of the three species examined, the females laid up to 65% fewer eggs than did the untreated populations. Mature spores of *N. locustae* can overwinter (presumably in cadavers). It is not known if the number of spores that survive is sufficient to reduce the population of grasshoppers in the year after application.

Cypermethrin and carbaryl were tested in the field as aqueous sprays and bran baits for control of third-instar grasshoppers in bromegrass and alfalfa–bromegrass pastures. Cypermethrin was applied at 4, 5, 8, 15, and 30 g/ha on bait and in spray, carbaryl was applied at 6, 15, 35, 110, and 200 g/ha on bait and at 20, 60, 120, 240, and 700 g/ha in spray.

In sprays, cypermethrin reduced the grasshopper populations by 97% and carbaryl at 700 g/ha by 90% within 120 h after application. Neither insecticide applied on bran bait gave adequate control of grasshoppers.

In 1982 and 1983, many growers in Saskatchewan complained about the lack of effectiveness of cypermethrin at the recommended dosage of 20–28 g/ha. Cypermethrin was tested in the laboratory at nine dosages from 2 to 72 g/ha, and at five temperatures from 15 to 35°C, against second- and third-instar nymphs of the migratory grasshopper. At rates up to 12 g/ha, mortality decreased as temperatures increased from 15 to 30°C, and then leveled off. At higher dosages, mortality increased slightly as temperatures were raised from 15 to 20°C, and then declined at higher temperatures. Cypermethrin was about 2.2 times less toxic at 35°C than at 15 or 20°C. About 70% of the reduction in toxicity occurred at temperatures above 25°C. Thus, the toxicity and effectiveness of cypermethrin as a control agent was negatively correlated with temperatures above 20°C for nymphs of the migratory grasshopper. Therefore, poor results can be expected from low dosages at high temperatures in the field.

Black flies

Saskatchewan species. Thirty-one species of black flies belonging to six genera, *Prosimulium*, *Cnephia*, *Ectemnia*, *Metacnephia*, *Stegopterna*, and *Simulium*, have been collected in Saskatchewan. Most species are seldom seen because they breed in small streams, produce only one generation per year, and either are nonbiting or bite only birds. Females of six species readily attack people. These are *Ectemnia taeniatifrons*, a rare species that emerges from the Saskatchewan River in May each year, and *Simulium decorum*, *S. griseum*, *S. luggeri*, *S. tuberosum*, and *S. venustum*. *S. vittatum* sometimes swarms densely around people but bites only non-hominid animals. *S. arcticum* is notorious for its widespread, fatal attacks on animals. It used to breed abundantly in rapids in the Saskatchewan River but has been largely replaced by *S. luggeri* since that river became shallow and weedy in the late 1960s. *S. luggeri* breeds continuously throughout the summer and tends to peak in abundance around midsummer unless larval infestations are reduced with insecticides. Although its bites seem not to be particularly toxic, it stresses animals severely when swarming abundantly. It also attacks people, sometimes forcing them to remain indoors.

On occasion, poultry have been severely attacked by at least three species, *S. euryadminiculum*, *S. meridionale*, and *S. rugglesi*. Losses of poultry have been attributed in most instances to loss of blood, and occasionally to infections by *Leucocytozoon*, a protozoan disease carried by black flies. Much remains to be done, particularly in improving means of preventing outbreaks, and direct protection of animals from severe outbreaks.

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Research Station, Swift Current, Saskatchewan

PROFESSIONAL STAFF

D.M. Bowden, BSA, MSA, PhD	Director
D.A. Smith[1]	Administrative Officer
G.E. Parker, BSA	Information Officer

Analytical Services

G.E. Winkleman, BSc	Head of Section; Chemist
C.T. Lund[2]	Systems Manager
S.D. Hanson[3]	Programmer/Analyst
K.E. Wilton,[4] BA, MLS	Librarian

Cereal Production and Utilization

T.F. Townley-Smith, BSA, MSc, PhD	Head of Section; Cereal breeding
J.M. Clarke, BSc(Agr), MSc, PhD	Harvest physiology
R.M. De Pauw, BA, MSc, PhD	Wheat breeding
D.G. Green, BSA, MS, PhD	Cereal physiology
C.W.B. Lendrum[5]	Programmer
T.N. McCaig, BSc, MSc, PhD	Quality physiology
J.G. McLeod, BSc(Agr), MSc, PhD	Rye breeding
R.E. Salmon, BSA, MSA, PhD	Turkey nutrition

Engineering

F.B. Dyck, BE, MSc	Acting Head of Section; Equipment design
D.W. Campbell, BE, MSc, PhD	Energy
Y.W. Jame, BSc, MSc, PhD	Irrigation
N.B. McLaughlin, BSc, MSc, PhD	Equipment design
H. Steppuhn, BSc, PhD	Subsurface hydrology
M.A. Stumborg, BE	Energy
S. Tessier,[6] BSc(Eng), MSc	Tillage

Forage Production and Utilization

T. Lawrence,[7] BSA, MSc, PhD	Head of Section; Grass breeding
N.W. Holt, BSA, PhD	Pasture management
P.G. Jefferson,[8] BSc(Agr), MSc	Legume breeding and physiology
J. Waddington,[9] BSc, MSc, PhD	Pasture establishment and physiology

Soils and Environment

C.A. Campbell, BSA, MSA, PhD	Head of Section; Soil chemistry and fertility
V.O. Biederbeck, BSA, MSc, PhD	Soil microbiology
A.J. Leyshon,[10] BSc, MSc	Forage fertility
F. Selles,[11] BSA(Chile), BSA, PhD	Soil fertility
R.P. Zentner, BSA, MSc, PhD	Economics

Departures

K.E. Dunkelgod, BS, MS, PhD Deceased 7 December 1984	Turkey nutrition
J.E. Knipfel, BSA, MSc, PhD Transferred to Prairie Regional Headquarters 2 January 1984	Ruminant nutrition
J. Looman, BSc, MSc, PhD Retired 17 October 1984	Range ecology
D.W. McAndrew, BSc, MSc, PhD Transferred to Vegreville Agricultural Station (Lacombe Research Station) 29 April 1984	Soil fertility
W. Nicholaichuk, BE, MSc, PhD Resigned 14 September 1984	Head of Engineering Section; Hydrology
A.W. Strachan, Transferred to Prairie Regional Headquarters 4 June 1984	Administration Officer

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[1]Appointed 30 July 1984.
[2]Seconded from Systems and Consulting Directorate, Finance and Administration Branch.
[3]Appointed 16 April 1984.
[4]Seconded from Libraries Division, Finance and Administration Branch.
[5]Appointed 9 April 1984.
[6]On Educational Leave, Washington State University, Pullman, Wash., 16 August 1984 to 16 August 1987.
[7]On transfer of work to Department of Scientific and Industrial Research (DSIR), Palmerston North, New Zealand, to 31 August 1984.
[8]On Educational Leave, Utah State University, Logan, Utah, 3 September 1984 to 3 September 1987.
[9]Transferred from Melfort Research Station on 18 October 1984.
[10]On Educational Leave, University of Saskatchewan, to May 1987.
[11]Appointed 1 October 1984.

INTRODUCTION

The Swift Current Research Station conducts a research program with a broad area of interest, even though centered in the Palliser Triangle of the Canadian prairies. Improvements in cereal and forage cultivars and technology to increase production and utilization efficiency are accomplished through a multidisciplinary approach involving plant breeding, plant physiology, agronomy, soil and water management, salinity control, nutrition, agrometeorology, agricultural engineering, and energy.

Considerable progress in plant breeding programs was reflected in the licensing of Heinrichs alfalfa, Kyle durum wheat, and Prima fall rye. Economics studies supported the value of investment of public funds in agricultural research because of the very high returns. The productive career of Dr. J. Looman in identifying and documenting the flora of western Canada ended with his retirement in 1984. Further significant publications that add to this documentation of the flora were published during the year.

The station was saddened by the sudden death of Dr. K. Dunkelgod, who had contributed significantly to providing new information on turkey nutrition and transferring it to the industry during his 17 yr of service to the station. Dr. J. Waddington transferred from the Melfort Research Station to work on forage crops with emphasis on problems of establishment. Dr. F. Selles joined the staff to work in soil salinity. Mr. D.A. Smith became the new administrative officer.

This report contains only brief summaries of research completed in 1984. More detailed information can be obtained from the publications listed at the end of this report, from *Research hi-lights* published by the station, or from individual scientists. Requests and correspondence should be addressed to the Research Station, Research Branch, Agriculture Canada, Box 1030, Swift Current, Sask. S9H 3X2.

D.M. Bowden
Director

CEREAL PRODUCTION AND UTILIZATION

Durum wheat

Kyle is a high-yielding durum wheat (*Triticum turgidum* L. var. *durum*) cultivar developed at the Agriculture Canada Research Station at Swift Current and Regina. In the cooperative tests Kyle outyielded Wakooma and Medora by 7% in the Brown and Dark Brown soil zones of Saskatchewan and Alberta, where durum wheat production is concentrated. In the Black soil zones of Saskatchewan and Manitoba it outyielded Medora by 3% and Wakooma and Coulter by 7%. It is a little later maturing, about 3 cm taller, and slightly more susceptible to lodging than Wakooma; however, none of these faults are serious in the major durum-producing area of the Brown soil zones. Kyle has medium-sized seed, good pasta quality, and has generally good disease resistance.

Hexaploid wheat

Losprout, a white-seeded spring wheat from the cross NB320/NB402//RL4137, has resistance to sprouting of grain in intact spikes greater than the moderately resistant white wheat Kenya 321.BT.1.B.1, comparable to red-seeded wheats like Pitic 62, Glenlea, and Neepawa but significantly less than RL4137. This germ plasm will provide wheat breeders with a basis from which to develop high-yielding, sprout-resistant, white-seeded wheat, thus allowing millers to produce a higher flour yield per unit of grain.

Nine spring wheat lines with improved resistance to common root rot combined with improved agronomic traits were developed through a cooperative project between Saskatoon and Swift Current research stations. These lines all had significantly less incidence of common root rot than Neepawa, hard red spring wheat. The nine lines differ substantially in field reaction to leaf and stem rust. Four lines yielded significantly more grain than the control cultivar Neepawa. All lines were equal to or later maturing than Neepawa. The lines differed in height, seed size, and photoperiod response. The milling and baking quality data indicate that the lines range in kernel hardness from soft to very hard and dough-mixing properties from weak to strong.

The improvement in resistance to common root rot can reduce the losses due to root rot, currently estimated to range from 5 to 15% annually in the wheat-growing area.

Harvest physiology

Effect of weathering on falling numbers of standing and windrowed wheat. Weathering damage, as reflected by falling number changes

in standing and windrowed red and white wheats, was compared in 14 cultivars grown in small plot trials and in four cultivars grown in field-scale trials. Weathering damage caused a broad range of falling number changes within both the red and white seed coat color classes of cultivars. Mean falling number for the weathering resistant white seed coat class exceeded that of the weathering susceptible red seed coat class in both years, indicating a range of genotypic expression of weathering resistance within both red and white wheats. Falling number was markedly lower in windrowed wheat than in standing wheat following weathering, particularly in the weathering susceptible cultivars. These differences were readily apparent, with total rainfall as low as 47 mm during the weathering period. The greater weathering susceptibility of the windrowed wheat than that of the standing wheat was attributed to higher moisture contents and slower drying, following rains in windrowed crops compared to standing crops. Test weight was unaffected by harvest treatment. Commercial grades were higher for weathered samples of standing wheat than for those of windrowed Neepawa wheat at one location. Based on quality of harvested grain, when weathering occurs during the harvesting period, direct harvesting with a combine is better than windrowing.

Rye breeding and genetics

Support of the Expert Committee on Grain Breeding (ECGB) for the licensing of RT141 was requested and received in February 1984. It was named Prima and subsequently licensed in July 1984 (License No. 2435). When seed supplies are available (fall of 1987) Prima could potentially be grown on 150 000 to 200 000 ha in western Canada.

Prima was selected from the hybrid combination Sangaste//Petkus/Dakold/3/Rysmin, which was produced in 1973. It was first entered in cooperative trials in 1980 as RT141.

The test data indicate that Prima represents a distinct improvement in yield over other cultivars available for use in western Canada. Winter survival is satisfactory, being about equal to Musketeer. The test mass (hectolitre weight) is equal to Musketeer, Puma, and Cougar and greater than Kodiak. The kernel mass is high (equal to Musketeer and Kodiak). It is about the same height as Puma and Musketeer, shorter than Kodiak, and taller than Cougar. Prima heads 2 days later and matures 1 day later than Frontier, the earliest check cultivar.

Canola meal and chicken flavor

The sensory quality of meat from broiler chickens fed diets containing canola meal, with or without added methionine and choline, or fish meal as well as methionine and choline, was evaluated by an experienced taste panel. Inclusion of up to 300 g/kg of canola meal in the diet did not affect flavor, juiciness, or tenderness. Inclusion of 50 g herring fish meal, 1 g added DL-methionine and 0.5 g choline chloride together with a high level of canola meal led to increased frequency of off-flavors, whereas supplementary methionine and choline in diets without fish meal did not affect sensory quality. It was concluded that the inclusion of canola meal at recommended levels in broiler diets is unlikely to affect the palatability of the resulting meat, but that 50 g/kg of herring fish meal may lead to off-flavors.

Comparative feeding value of triticale and wheat for poultry

True metabolizable energy (TME) values of triticale and wheat averaged dry matter at 14.8 and 15.1 kJ/g, respectively. Triticale protein contained more lysine, arginine, aspartic acid, and alanine than wheat protein. One of two triticale samples linearly depressed liveweights at 38 days when fed to Small White turkeys at 0, 150, 300, and 450 g/kg as a direct substitute for wheat. Ergot contamination was eliminated as a possible cause of the growth depression. Levels of pentosans in triticale was considered as a possible cause of growth depression. This observation gives reason for caution in the incorporation of high levels of triticale in poultry diets.

Nutritive value of feedstuffs for poultry

True metabolizable energy (TME) values and ranges, and dry matter contents of 133 samples of 14 feedstuffs were summarized to provide data of value in practical feed formulation. The TME value of the high-fat feedstuff, full-fat canola meal, was found to vary inversely to its proportion in the test sample, ranging from dry matter at 22.5 kJ/g as the sole feedstuff to 26.2 kJ/g when blended with 75% wheat.

Protein requirement of turkey broilers

Improved growth potential of turkeys of broiler strains, resulting from advances in breeding, prompted a reappraisal of their protein requirement for optimum performance. Turkeys of a Small White strain, fed a common starter diet to 28 days of age, were given three grower diets

containing protein ranging from 220 to 255 g/kg, and three finisher diets containing protein ranging from 162 to 197 g/kg, in a factorial experiment. Carcass fat and fleshing scores increased with higher finisher protein. Meat yield tended to increase and bone yield decreased, relative to eviscerated carcass weight, with higher finisher protein. Protein requirement for optimal weight gain from 28 to 70 days of age was at least 255 g/kg with diets having a TME value of 13.9 MJ/kg. The protein required by males was 197 g/kg and by females at least 182 g/kg, with TME at 13.9 MJ/kg from 70 to 91 days. Feeding programs incorporating less dietary protein may adversely affect carcass quality, growth, and feed efficiency.

ENGINEERING

The Swift Current 50 kW vertical axis wind turbine has been operating as a joint project between the National Research Council of Canada, the Saskatchewan Power Corporation, and Agriculture Canada. Considerable operating experience has been gained since the prototype was first installed in 1978. Although many unforeseen operational problems developed, this experience has led to improved designs. Most of the problems encountered have proved to be minor but have had a detrimental impact on the reliability of the unit. Changes were incorporated to improve the safety of the turbine.

The turbine is instrumented to obtain both performance data and stress data from the blades. Both averaged and instantaneous performance data are monitored. Analysis of data collected from the two anemometers, the shaft torque, shaft speed, and the voltage and power characteristics of the motor-generator is presented in terms of performance characteristics for the turbine.

The conclusion is that this turbine can be operated safely but with questionable reliability.

FORAGE PRODUCTION AND UTILIZATION

Alfalfa

Cultivar × rowspacing interaction. Ten alfalfa (*Medicago sativa* L., and *M. falcata* L.) cultivars were grown in 30- and 90-cm row spacings on a dryland site at Swift Current, Sask. From 1979 to 1981 there was a significant cultivar × spacing interaction on yield at every harvest except the second cutting in 1981. The *M. falcata* cultivars, Anik and Sc Mf 3713, were better able to exploit the lower plant density at the 90-cm spacing than *M. sativa* cultivars, Thor and Banner. Yields of Anik and Sc Mf 3713 increased with 90-cm compared to 30-cm spacing, whereas Thor and Banner decreased. The creeping-rooted cultivars Rambler and Rangelander did not differ from Anik or Sc Mf 3713 in yield response to increased row spacing. This suggests that the observed cultivar × spacing interaction was due to morphological and/or physiological traits associated with the *M. falcata* cultivars, other than the creeping-rooted habit.

Harvesting irrigated alfalfa in establishment year. In a study involving four alfalfa (*Medicago sativa* L.) cultivars, Beaver, Roamer, Dupuits, and Alfa, establishment year harvesting reduced the subsequent yields of Beaver and Alfa cultivars in the 1976 and 1977 seedings. There were no significant effects in 1978, 1979, and 1981 seedings from establishment year harvesting. It was noted when significant yield reductions did occur in the post-establishment yields that the establishment year yield compensates and the total production of the stand is not affected. Roamer was superior to Beaver, which was better than Alfa and Dupuits in winterhardiness at this location. Variation in the yield response to establishment year treatments among seeding years indicated that these types of trials should be sequentially seeded for at least 3 yr to evaluate management × environment interaction effects on perennial crops.

Heinrichs alfalfa. The alfalfa cultivar Heinrichs (*Medicago media* Pers.) (Reg. No. 139) was developed at the Agriculture Canada Research Station, Swift Current, Sask. It was tested experimentally as Sc 3702 and was licensed for use in Canada in October 1981.

Heinrichs is a 12-clone synthetic resulting from two cycles of recurrent selection for low leaf-stem ratio within crosses among the cultivars Rambler, Roamer, their parental stocks, and five introductions of *Medicago sativa* L., from the USSR: SC 16113 (Kamalinskaia 930 from the Krasnodar region), SC 16131 (Zabaikalka from Chita region), Sc 16132 (Pestrogibridnaia from Kazakhstan), Sc 16136 (Omskaia 2251 from the Omsk region), and Sc 16150 (Livlinetskaia from the Ukraine). Large vigorous plants were selected and subsequently screened for resistance to bacterial wilt caused by *Corynebacterium insidiosum* (McCull.) H.L. Jens. Although the original selection criterion was a low leaf-stem ratio under greenhouse conditions, the resulting population is similar to other cultivars in protein content.

Heinrichs is an erect-growing, hay-type cultivar that produced 10% more dry matter than

Rambler and is equal to it in winterhardiness. It should replace Rambler for hay production in the Brown and Dark Brown soil zones of Saskatchewan and Alberta. It will be particularly useful in hay-land situations where stands are retained for extended periods. Heinrichs is creeping-rooted, variegated in flower color, and the plants exhibit the broad crowns typical of winter-hardy genotypes. Seed yields are about 12% less than Rambler. Heinrichs has the same level of resistance to bacterial wilt as Drylander and is only slightly lower than Beaver. It is recommended as a hay crop to be seeded alone or in alternate rows with intermediate wheat grass or crested wheat grass.

The vegetation of the Canadian Prairie Provinces

The woody vegetation, Part 1. Descriptions of the shrub communities of the dryland habitats have been published. Dryland shrub communities usually form transitions between the various grasslands and woodlands. Well-developed communities are shown to be closely related to similar communities of Eurasia, and can be placed with these communities in the class group Rubo-Rosca. One class, with 2 orders, 4 alliances, 14 associations, 12 subassociations, and several variants and unclassified communities are recognized and described.

The biological flora of Canada. Shepherdia argentea (Pursh) Nutt., silver buffaloberry, is a usually armed shrub or small tree, which occurs primarily along streams and lakeshores, and in coulees and ravines of the southern parts of the Prairie Provinces, where it appears to be limited to altitudes below about 1000 m. Commonly, it forms more or less dense shrub communities with up to eight other species in dry-mesic sites, and up to 10 species in mesic sites. Flowering begins from late April to early May and berries ripen in late July to mid-August. Germination in fresh seed varied from 26% to 76% but low reproduction appears to be more important in determining current distribution. Plains Indians used the berries both fresh and dried; now it is occasionally used for jams, jellies, and wine.

SOILS AND ENVIRONMENT

Interaction of N fertilizer, temperature, and duration and stage of moisture stress on growth kinetics and moisture-use efficiency of Manitou spring wheat

It appears that, as was found in the analysis of the yield and protein results, optimum temperature for spring wheat is about 22° C. If we disregard the longer period required to attain maturity, then cooler than optimum temperature might be preferable to warmer than optimum because of the higher yield and more efficient use of water. This choice might be reversed in the more northern portions of the Prairie Provinces because the length of the growing season (frost-free days) decreases. These conclusions are in agreement with general observations in the field.

When Manitou spring wheat was subjected to moisture stress from early in its growth to maturity, it appeared to be able to adapt to such stress more readily than when subjected to it in mid-growth or later. When plants were subjected to moisture stress from early growth, water use efficiency was increased because leaves senesced earlier. These plants also seemed to translocate assimilates from stalks to heads more efficiently than did plants stressed from later in their development. This probably explains why grain yields were greater in plants stressed from tillering than when plants were stressed from lymphoid leukosis virus (LLV), and why the harvest index was higher for plants stressed from tillering than from all other treatments. The information provided by this study will probably find its greatest use in the development of simulation models. Basic relationships for the interactions of temperature, N, and soil moisture on the growth of spring wheat have been presented. Although the values obtained in laboratory experiments cannot be transferred directly to field conditions, they do provide an indication of the general magnitude and a good qualitative descriptive relationship on which simulation models can be based and proofed by field experimentation.

Agrispon tested and found wanting

Assessment of the fertilizer supplement Agrispon indicated that the product is useless, because it increased production costs without any increase in yield. Agrispon has been promoted as a replacement for or supplement to applied fertilizer nitrogen and as a germination stimulator. None of these effects were found when the product was evaluated in replicated experiments, using wheat as a test crop.

The product's microbial composition was also evaluated. Microbes present were typical of those commonly found in soils. Action of the product is claimed to be attributed to its microbial components. However, if applied as the promoter suggests, then one new microbe per fifteen million microbes already present in the surface 2.5 cm of soil would be added. It is unlikely that one microbial cell could dominate or affect so many others.

Agrispon promoters also suggested adding 30% of the soil-test-recommended fertilizer nitrogen plus Agrispon. In field experiments, this resulted in the same yield increase as if 30% of the recommended fertilizer nitrogen had been applied without Agrispon. Influence of Agrispon on wheat emergence was also evaluated, with the effect being exactly the same as adding distilled water. In all evaluations, Agrispon had no effect on grain yield, rate of emergence, protein content, dry matter yield, or soil nitrogen levels.

Effect of fertilizer on soil pH after 17 yr of continuous cropping

When nitrogen fertilizer was applied for 17 yr to annually grown spring wheat at relatively low rates (N at 35 kg/ha per year), the surface soil that was initially only slightly acid became quite acid. In fact, the pH of the top 15 cm of this soil dropped by about 0.5 pH unit during 17 yr.

It is well known among soil scientists that any high nitrogen source such as fertilizers, manure, and legumes, when added to soil, can promote acidification over a long period. Nonetheless, with the relatively low rates of fertilizer used in these studies, the decrease in soil pH in long-term crop rotation plots that had grown wheat was surprising. Furthermore, the soil in the plot areas is a loam with good clay content. Clays tend to buffer the soil against sudden large changes in pH.

These findings do not suggest that there is an immediate problem, because only the top 15 cm of the soil are affected, whereas the roots of wheat spread throughout the top 120 cm of soil. However, recently some soil scientists have been recommending an increase in the use of annual cropping (i.e., continuous cropping) so as to reduce soil degradation. Annual cropping will mean greater use of fertilizers. Results from the Swift Current study indicate that continual use of nitrogen fertilizers, even at low rates, could eventually result in problems we did not have before. Degradation of the soil would be reduced, but there could be a need to apply lime to maintain a favorable soil pH.

Mineralization rate constants and their use for estimating nitrogen mineralization in some Canadian prairie soils

In the area of soil fertility management and environmental pollution there is need to know the amount of N that will be mineralized during the cropping season. However, the interplay of biological, physical, and environmental factors that often affect N mineralization makes this system a difficult one to analyze.

Even before fertilizer use became a significant factor in crop production, scientists were trying to develop ways to assess the relative N-supplying capacities of soils as influenced by cultural and management practices. Over the past 50 yr a number of empirical methods to do this have been developed. These tests provide relative values that do not predict the amounts of N mineralized reliably. Part of the limitations of such tests is that they provide single values that do not reflect variations due to weather conditions.

Perhaps the most progress in this area of research has been made by the late George Stanford and his American coworkers. They have managed to quantify net N mineralized as a function of moisture, temperature, and a capacity factory called the potentially mineralizable N. Work at Swift Current has adapted Stanford's approach for assessing N mineralization in some prairie soils.

Data were published on the potentially mineralizable N and related moisture functions for the 18 prairie soils examined and temperature functions have now been developed. A model was developed for estimating mineralized N by combining the three aforementioned components and it was tested successfully, using data derived previously during soil incubations carried out under controlled conditions in the laboratory and field. These results remain to be tested under in situ conditions in the field but they appear quite promising.

Benefits of agricultural research

A study was completed to determine whether public investment in Canadian wheat research activities made over the period 1949–1979 constituted socially profitable use of scarce public resources, and to what extent the social benefits from these research activities have accrued to producers and to consumers, respectively. Two research scenarios were examined—one dealing with the development of new wheat varieties and the other dealing with all research applicable to the production of spring, winter, and durum wheats. The results revealed that society has indeed benefited substantially from public investment in wheat research. The level of social benefits averaged $49 and $143 million (measured in constant 1971 dollars) annually for the wheat breeding and all wheat research scenarios, respectively. The average annual internal rates of return earned from these investments ranged between 30 and 39% (above the rate of inflation). These rates of return were generally much higher than those typically earned on most ordinary business investments and from those realized on

most other types of public investment opportunities. Furthermore, the results indicated that society may, in fact, be underinvesting in agricultural research in the aggregate and that substantial social benefits would likely accrue from increased public investments in agricultural research. Finally, analyses of the distribution of the benefits from publicly funded wheat research showed that both producers and consumers were major beneficiaries. Consequently, on the basis of equity, all members of society should continue to contribute to the research investment costs.

Effect of crop rotation and fertilization on soil quality

Effects of rotation length and N and P fertilizer on some physical and biological properties of a Brown Chernozemic loam were determined over a 16-yr period. The results indicate that both amount and quality of surface soil organic matter can be improved with available agronomic technology. Frequent summerfallowing was confirmed as the main culprit of the increasingly serious degradation of prairie soils.

The amount of trash conserved decreased and soil erodibility increased with more frequent summerfallowing, emphasizing the need to keep the soil covered with a crop or residues. Organic nitrogen in surface soil increased from 0.18% to 0.20% over 16 yr in properly fertilized continuous wheat but not in fallow–wheat rotations. This N increase was credited partly to fertilizer additions and partly to more efficient use and cycling of subsoil nitrate via plant roots and crop residues. After 10 yr, well-fertilized continuous rotations contained 13% more soil organic carbon than fallow rotations and continuous wheat receiving only P fertilizer. There were quantitative and qualitative improvements in microbial populations and activity with extended cropping and proper fertilization. It was concluded that soil quality can be improved by a combination of extending the rotation length (cropping annually), applying N and P fertilizers at rates normally recommended by soil test laboratories, and by using a stubble mulch tillage technique. Thus, it is possible to reverse the recently publicized "agonizing" degradation of Brown soils and stabilize grain production.

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Research Station, Beaverlodge, Alberta

PROFESSIONAL STAFF

L.P.S. Spangelo, BSA, MSc, PhD	Director
W.H. Marshall	Administrative Officer
M.B. Woytuik	Computer Systems Manager
E.T.W. Hau,[1] BSc(Agr), MLS	Librarian

Cereal and Oilseed Crops

R.I. Wolfe, BSA, BD, PhD	Head of Section; Cereal breeding
R.S. Sadasivaiah, BSc, MSc, PhD	Rapeseed

Environment and Soils

W.A. Rice, BSA, MSc, PhD	Head of Section; Microbiology
M.A. Arshad, BSc, MSc, PhD	Soil physics
A.L. Darwent, BSA, MSc, PhD	Weed control
J.G.N. Davidson, BSF, MSc, PhD	Plant pathology
J.S. McKenzie, BSA, MSc, PhD	Plant survival
P.F. Mills, BA	Micrometeorology
Y.K. Soon, BSA, MSc, PhD	Soil chemistry

Forage Crops and Apiculture

S.G. Bonin, BSA, PhD	Head of Section; Grass breeding
D.T. Fairey, BSc, MSc, PhD	Legume seed physiology
N.A. Fairey, BSc, MSc, PhD	Forage production
H.G. Najda, BA, BSc, MPM	Grass seed management
D.L. Nelson, BSA, MSc	Head of Unit; Apiculture
T.P. Liu, BSc, MSc, PhD	Apiculture pathology
T.I. Szabo, BAE, MSc, PhD	Apiculture

Experimental Farm, Fort Vermilion, Alta.

B. Siemens, BSA, MSc	Superintendent; Forage crops
G.W. Clayton, BSA, MSc	Crop production

VISITING SCIENTISTS

Agricultural Research Council of Alberta

J.V. Christensen, BSA	Cereal agronomy
D.W. Sippell, BSc, MSc	Canola pathology

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[1]Seconded from Libraries Division, Finance and Administration Branch.

INTRODUCTION

The Northern Research Group, comprising the Research Station at Beaverlodge and the associated Experimental Farm at Fort Vermilion, Alta., continued its reponsibility for research on agricultural problems in northwestern Canada. This report presents highlights of research for 1984.

A major accomplishment was identification of a primary cause of brown girdling root rot of canola. This disease has caused economic losses up to 60% in individual fields. Strategies to control this disease can now be developed.

Our microbiology team has determined that inoculant manufacturers cannot combine the BALSAC and NRG-185 strains of Rhizobium into one inoculant because it could negate any yield advantage the individual strains have on a regional basis.

Initiation of the urgently needed research in soil physics and in grass seed management was made possible by the addition of Dr. M.A. Arshad and Mr. Henry Najda, respectively.

Detailed information can be obtained from the publications listed in this report. Correspondence to individual research scientists should be addressed to the Research Station, Research Branch, Agriculture Canada, Box 29, Beaverlodge, Alta., T0H 0C0, and the Experimental Farm, Research Branch, Agriculture Canada, Fort Vermilion, Alta., T0H 1N0.

L.P.S. Spangelo
Director

APICULTURE

Breeding

Inseminating honey bees. Sister queen honey bees (*Apis mellifera*), 59 instrumentally inseminated (IIS) and 59 naturally mated (NM), were produced in Baton Rouge, La., and put into field colonies at three locations in Alberta, Canada, and at one location in Louisiana, USA. Survival of the IIS queens was lower than that of the NM queens; 37 IIS queens and 50 NM queens survived from August 1981 to May 1982, and 18 IIS and 34 NM queens survived until August 1982. At all four locations, the colonies with NM queens had 21–73% more capped brood in May (February in Louisiana) than did colonies with IIS queens.

Probably because of this difference in brood production, the colonies with NM queens produced more honey. Over a 12-mo period, the mean loss of spermatozoa from IIS queens was 0.9 million (28% of the original number in the spermatheca), and the mean loss for NM queens was 1.5 million (27%).

Management

Quality of honey bees. The relationship between queen weight, queen attractiveness, sealed brood area, and colony honey production were investigated. Queens' attractiveness to workers varied greatly but was not correlated with any of the other measured parameters. Queen weight, 18 h after removal from mating nuclei, averaged 214 mg and decreased to 208 mg after 8 days of storage and transit. At the peak of the honey flow, the average queen weight had increased to 293 mg. Honey production was correlated positively both with sealed brood area and with queen weight after removal from the mating nuclei. A practical method of eliminating some of the less productive queens would be to remove them from the mating nuclei when about 12 days of age and discard the lightest 15–25%.

The effect of queens on honey production. Colonies with queen loss, queen failure, and those that swarmed, produced less honey than did normal colonies. There was also less brood reared in colonies in which there was queen loss or queen failure, but brood production, up to the time of swarming, was 16% greater in colonies that swarmed than in normal colonies. On average, honey production in colonies with queen-related or swarming problems was only 58% of normal. This demonstrates the importance of eliminating these types of problems whenever possible.

Pathology

Nosema apis. Nosema apis is a parasitic protozoa that can kill up to 35% of an overwintering honey colony. In electron microscope studies, virus-like cytoplasmic particles have recently been observed in lysed spores of *Nosema apis* within the midgut of the honey bee. Work is ongoing to determine the effect of these particles on *Nosema apis*.

Ultrastructure of Nosema apis-infected bees. Midgut epithelial cells from healthy bees possessed numerous mitochondria, strands of endoplasmic reticulum, evenly distributed ribosomes,

zymogen granules, and two kinds of lipid inclusions. In heavily infected midguts of honey bees, all epithelial cells were observed to be infected with *Nosema apis*. Cells of the entire midgut were packed with mature spores and, in some cases, mixed with immature stages. Spores were not found among cells of the brush border and basal infolding. Muscle cells and tracheal end cells of the midgut were not infected. The cytoplasm of the infected cells contained a large number of vacuoles, numerous large inclusion bodies, and aggregated ribosomes. Signs of extensive lysis were observed within the heavily infected cells, although the cell membranes were intact.

CEREALS

Agronomy

Effect of harvest time and drying method. Two hard red spring wheat (*Triticum aestivum* L.) cultivars, Neepawa and Columbus, were harvested at 5% kernal moisture content (KMC) intervals from 45% to 15% for three growing seasons. Two drying treatments, field drying in windrows and oven drying, were evaluated. Yield, test weight, 1000-kernel weight, protein-N, falling number, and commercial grade were determined. Protein-N and 1000-kernal weight were reduced when the crop was harvested above 40% and 35% KMC, respectively, but they were not affected by drying method. Yield losses up to 12% were recorded with windrowing. Windrowing at 35%, or less, KMC in warm, dry conditions had little effect on test weight, falling numbers, and grade. Under wet conditions, windrowing above 20% KMC resulted in lower falling numbers, and a loss of grade. Direct combining and artificial drying above 20% KMC lowered test weights, falling numbers, and grade. The current recommendation of windrowing at 35% KMC is supported under good harvest conditions but either windrowing or straight combining at 20% KMC would be superior under damp harvest conditions.

Effect of seeding date, rate, depth, and row spacing. Studies were conducted on the effects of seeding dates, rates, depths, and row spacings on the growth and yield of canola. Seeding dates of mid-May and mid to late May for Argentine and Polish cultivars, respectively, provided the highest average yields over several years, although potential yields were higher with earlier seeding. Increasing seeding rates reduced days to maturity and a seeding rate of 9 kg/ha maximized yields. A seeding depth of 25 mm is optimal for fast emergence and yield. Preliminary results indicated a narrow row spacing of 7.5 cm increased canola yields.

Diseases

Root rot in canola. Brown girdling root rot is the principal disease of canola in the Peace River region of Alberta and British Columbia. Until now, the cause has been undetermined. *Rhizoctonia solani*-like mycelium was seen in most root rot lesions from field grown plants. Hyphae of other fungi were also present in some instances. Portions of lesioned roots were excised, surface sterilized, and plated on either a general or selective agar medium. *R. solani*, *Fusarium roseum*, *F. Tricinctum*, and *Phythium ultimum* were isolated with frequencies of about 22, 12, 8, and 1%, respectively, from 400 roots. Isolates of *R. solani* were purified and tested for pathogenicity to *Brassica campestris* 'Tobin.' Canola was grown in Spence-Lemaire root trainers containing soil pasteurized at 60°C for 30 min and inoculated by placing mycelial discs on roots at a 3-cm depth, 3 wk after planting. Check plants were inoculated with sterile agar discs. Plants were incubated at 8 to 15°C, watered daily, then harvested after 6 wk. An average of 59% of the plants inoculated showed root rot symptoms similar to those seen in the field. No lesions were found on check plants grown in pasteurized soil. *R. solani* recovered from 90% of lesions induced by inoculation tests. These results provide the first experimental evidence that *R. solani* is a primary cause of brown girdling root rot.

ENVIRONMENT AND SOILS

Nitrogen fixation

Nitrification inhibitors. Loss of nitrate-N by denitrification and leaching may be prevented by adding nitrification inhibitors to ammonium-based nitrogen fertilizers. However, compounds that are effective nitrification inhibitors may also affect other soil microbial processes. Field and laboratory experiments were conducted to determine the effect of nitrification inhibitors on soil microbial populations and nitrogen transformations. Potassium methy xanthate (KMX) and sodium trithiocarbonate (STC) were tested in field experiments. These inhibitors tended to lower the populations of nitrifiers in field soils, but the effect was not large and occurred only during the early part of the growing season. In laboratory studies 2-chloro-6-(trichloromethyl) pyridine (nitrapyrin), 5-ethoxy-3-trichloromethyl-1, 2, 4-thiadiazole (etridiazole), dicyano-

Research Station, Beaverlodge, Alta.

diamide (DCD), and potassium methyl xanthate (KMX) were examined for their effect on soil microbial populations and nitrogen fixation. These four inhibitors were shown to have varying effects on nitrogen fixation by soil and alfalfa. Nitrapyrin, etridiazole, and DCD reduced nitrogenase activity and nodule development when applied at rates equivalent to 10 times the rates normally recommended for inhibition of nitrification. However, KMX reduced soil microbial populations, nitrogenase activity in soil and nodules, and the nodulation of alfalfa. The effect of KMX was temporary, lasting less than 32 days under laboratory conditions. The results indicate that KMX has potential for affecting the nitrogen-fixation process in soil. This should be considered in the evaluation of the effectiveness of this compound for conserving fertilizer-N.

Plant survival

Critical harvest period. Fall cutting management studies confirmed that the "critical harvest period" for alfalfa in northern Alberta is August and early September. Plants harvested during this period have an increased potential for winterkill and reduced yields the following year. Proper fall cutting management, however, did not signficantly increase the longevity of a stand. The cultivar Peace was less susceptible to winter injury than Beaver, Rambler, and Anchor when harvested during the critical harvest period.

FORAGES

Weed control

Tolerance of seedling stands of forage grasses to herbicides. In a 4-yr study, seedling stands of creeping red fescue, bromegrass, and timothy were tolerant to several herbicides when applied at the two- to four-leaf stages of the grasses. The herbicides were bromoxynil, bromoxynil plus MCPA, Dowco 290, Dowco 290 plus 2,4-D, flamprop methyl, and linuron plus MCPA. Seedling stands of fescue and bromegrass were also tolerant to cyanazine plus MCPA, but timothy was injured. All three grasses were injured by metribuzin and chlorsulfuron. Creeping red fescue exhibited tolerance to sethoxydim, fluazafop butyl, haloxyfop methyl, and several other new herbicides for grassy weed control, whereas bromegrass and timothy were severely injured by all these products.

Use of either a roller or a rope wick applicator. In a 3-yr study, annual weeds protruding above the top of seedling stands were effectively controlled by glyphosate (Roundup) applied with a roller or with a rope wick applicator. The method appears to have greatest economic potential when annual weed infestations are of low density. Quack grass growing in a field of fallow was not as effectively controlled by glyphosate when applied with either a roller or a rope wick applicator as when applied with a conventional sprayer. Differences in the control of annual and perennial weeds obtained with the roller applicator and with the rope wick applicator were not consistent. However, the rope wick applicator appeared to use less herbicide, was cheaper to operate, and cheaper to purchase than the roller applicator.

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Research Station, Lacombe, Alberta

PROFESSIONAL STAFF

D.E. Waldern, BSA, MSA, PhD	Director
D.D. Jones	Administrative Officer

Animal Science

J.A. Newman, BSc, DipAnGen, PhD	Head of Section; Beef cattle breeding
A.P. Sather, BSc, MS, PhD	Swine breeding and management
A.K.W. Tong, BSc, MSc, PhD	Beef cattle breeding and management (ROP)

Meats

A.H. Martin, BSA, MSA	Head of Section; Meat science
H. Doornenbal, BSA, MSA, PhD	Physiology
G.G. Greer, BSc, MSc, PhD	Microbiology
L.E. Jeremiah, BS, MS, PhD	Food technology
A.C. Murray, BSc, PhD	Biochemistry

Cereal Breeding, Pathology, and Forage

L.J. Piening, BSc, MSc, PhD	Head of Section; Cereal pathology
V.S. Baron, BSc, MSc, PhD	Forage physiology
W.B. Berkenkamp, BSc, MS, PhD	Forage crops, forage pathology
S. Kibite, BSc, MSc, PhD	Barley, oat, wheat breeding

Crop Management and Soils

P.A. O'Sullivan, BSc, PhD	Head of Section; Weed physiology
S.S. Malhi, BSc, MSc, PhD	Soil chemistry

Scientific Support

L.R. Fobert	Systems and programming
D. Lamkin	Computer programming

Soils and Crops Substation, Vegreville

D.W. McAndrew, BSc, MSc, PhD	Officer in Charge; Soils
J.R. Pearen, BSc, BEd, MSc	Forage crops

Departures

H.T. Fredeen, BSA, MSc, PhD, FAIC July 1984	Animal breeding
M.L. Kaufmann, CD, BSA, MSc, PhD September 1984	Head of Section; Barley, oat breeding
R. Morgan, BSc, MLS November 1984	Librarian
G.M. Weiss, BSA, MSc January 1984	Head of Section; Data processing

INTRODUCTION

The Lacombe Research Station and the Soils and Crops Substation at Vegreville are responsible for regional agricultural research in the central Alberta parklands. Specifically, programs include soil reclamation and development of cropping practices for Solonetzic soils of east-central Alberta; breeding new, high-yielding, disease-resistant feed barley and oat varieties for domestic use and export; and developing soil fertility, soil management, weed control, and cropping systems for barley, oat, and rapeseed production in the parklands. The station has regional responsibility for production and disease research of annual forage crops, specifically screening and selecting species and varieties that will be used by beef and dairy farmers for silage and pasture to give optimum yield per hectare of digestible energy. The Lacombe program also includes research responsibility for regional and national programs in swine and beef cattle breeding; the technical research aspects of record of performance (ROP) beef cattle and swine testing programs; and major carcass evaluation research related to national departmental beef and swine carcass grading programs. The meats research includes work on the physical, chemical, microbiological, and sensory aspects of beef and pork quality in relation to pre- and post-slaughter conditions and carcass management, both at the meat-packing plant and at the retailer level, and with consideration given to cooking quality and other factors related to consumer acceptance of the final product. Two outstanding senior scientists retired in 1984. Dr. Howard Fredeen, Animal breeder, renowned for his co-development of the Lacombe hog and major contributions to the national beef and hog grading standards, retired in July. Dr. Martin Kaufmann, recognized for his development of Park wheat, four oat varieties including Cascade, and for Diamond barley, retired in September 1984.

This report summarizes the highlights of research completed in 1984. Further information on any of these research activities, reprints of publications listed in this report, and copies of previous reports may be obtained from the Research Station, Research Branch, Agriculture Canada, Box 1420, Lacombe, Alta. T0C 1S0.

D.E. Waldern
Director

ANIMAL BREEDING

Beef cattle

Environmental correlation between pretest and station test average daily gain (ADG). Station performance testing involves comparisons at one location of young bulls previously reared on a number of different farms. Considerable concern has been expressed about pretest environmental effects that may invalidate comparisons of gains during the test period. Data used in this study were obtained from 1675 crossbred male and female calves from Hereford, Angus, and Shorthorn dams and sired by 20 Charolais, 12 Simmental, and 15 Limousin sires. The calves were born and raised to weaning in 45 herds from Alberta, Saskatchewan, and Manitoba between 1969 and 1972. After weaning, the calves were transported to either Lacombe Research Station or Brandon Research Station for performance testing. There was significant herd-year variation with a range in pretest ADG of 0.38, 0.28, and 0.15 kg for Hereford, Angus, and Shorthorn herd-years, respectively. Genetic and environmental variances and covariances were estimated from a model, which included fixed effects of herd-year, sex of calf, breed of sire, and random sire within breed of sire effects. The environmental correlations between pretest ADG and ADG at 28-, 56-, 84-, 112-, and 140-day of test were −0.08, 0.03, 0.03, 0.03, −0.01, and −0.09, respectively. Correlations of this magnitude suggest that the performance of calves centrally tested at the Lacombe and Brandon research stations was independent of the pretest herd environment.

Swine

Recovery from leg weakness in pigs transferred from confinement housing to pasture lots. Leg weakness is a major problem in hogs reared in confinement. It is generally assumed that the transfer of potential breeding stock from confinement housing to pasture lots can alleviate much of their leg weakness. However, this is based on reports that are usually limited to pigs with initial leg weakness problems. Structural soundness of 314 Lacombe boars at 90 kg and 371 gilts at 140 days of age were evaluated as they were transferred to pasture lots from confinement test barns. The pigs were rescored 3 mo later to determine if pasture maintenance had any effect

in reducing the incidence of leg weakness. Initially, 55% of the boars and 76% of the gilts showed no leg weakness. At rescoring, 56% of the boars and 84% of the gilts showed no leg weakness. However, of those boars that initially demonstrated leg weakness symptoms 21% had become sound by the time of rescoring, but 15% of the sound boars had developed weakness. Amongst gilts, 76% of those with leg weakness had acquired normal scores at rescoring, whereas 13% of sound gilts had developed leg weakness.

This study suggests that a certain proportion of pigs with leg weakness will improve while being housed in pasture lots, but that placing animals on pasture may not remove leg weakness as one of the serious problems of the swine industry.

Meat biochemistry

Toluene as an alternative to benzene in the Woessner determination of hydroxyproline. Intramuscular collagen content is usually estimated through the chemical determination of 4-hydroxyproline, an amino acid confined essentially to connective tissue proteins. The Woessner (Arch. Biochem. Biophys. 93,440 (1961)) modification of the Stegemann (Hoppe-Seyler's Z. Physiol. Chem. 311,41 (1958)) procedure is the most frequently used method for the determination of hydroxyproline in meat. This approach involves extractions with benzene, a solvent known to be chronically toxic and carcinogenic, even at concentrations too low to detect through smell. Its use may be prohibited, discouraged, or permitted with extreme caution. An experiment was designed to determine if toluene is an acceptable alternative to benzene in this procedure. Toluene extractions yielded slightly higher absorbance values for both hydroxyproline standards and unknown meat samples. Hydroxyproline contents for meat samples, obtained from the longissimus dorsi muscle of 15-mo-old steers, ranged from 114 to 381 and from 1080 to 1939 for salt-soluble and salt-insoluble fractions, respectively. The mean difference between the hydroxyproline contents from the two extraction procedures was small and nonsignificant. These data suggested that toluene is an acceptable alternative to benzene for the extraction of interfering substances in the Woessner procedure for the quantitation of intramuscular hydroxyproline.

Physiology

The relation of blood serum components in the growing pig to performance, development, and carcass composition parameters. Growth studies were conducted on 65 barrows and 55 gilts. Half of the pigs were fed ad libitum and half were fed restricted, i.e., fed to appetite twice a day for 30 min. The animals were serially slaughtered at 2-wk intervals from 85 days to 138 days of age and blood samples were obtained by exsanguination. Twelve serum components were determined on a Technicon SMA II system. Age had the most pronounced effect on the parameters studied, with urea, calcium, bilirubin, creatinine, serum protein, and albumin showing a significant increase ($P < 0.01$) with age. Pigs fed ad libitum had a higher level of urea, calcium, and phosphorus but a lower level of creatinine than the restricted fed pigs. After adjusting for sex, feeding regime, and age of slaughter group, calcium was significantly correlated with backfat (0.30) and loin fat (0.36), average daily gain (0.42), feed conversion (-0.39) and percent dissectible bone (-0.39); similar correlations existed between these traits and total blood protein. Serum albumin was highly ($P < 0.01$) correlated with ultrasonic backfat (0.35) and loin fat (0.40), average daily gain (0.73), feed conversion (-0.68), feed intake (0.29), and percent dissectible bone (-0.53).

Microbiology

The effects of wholesale and retail contamination on the retail case life of beef steaks from wholesale beef ribs were examined under simulated extremes of retail processing sanitation, using regression analyses. The analyses showed that a greater percentage of the variability in steak case life could be attributed to steak ($r^2\% = 43.2$) and rib ($r^2\% = 44.9$) bacterial counts than to the level of contamination on retail processing equipment ($r^2\% = 24.6$). The greatest proportion of the variation in retail case life was due to the combined influence of steak plus rib bacterial counts ($r^2\% = 62.4$) and rib plus equipment bacterial counts ($r^2\% = 58.1$). The variation in case life attributable to steak bacterial counts alone ($r^2\% = 43.2$) only slightly increased ($r^2\% = 45.1$) when both steak plus equipment bacterial counts were considered. The contribution of steak plus rib bacterial counts to the variation in steak case life ($r^2\% = 62.4$) did not change when equipment bacterial counts were also included in the regression analysis. According to the results of this study, wholesale contamination was determined to be one and one-half times as important as was retail sanitation in determining shelf life.

Although steak case life could be predicted as a function of both steak and rib bacterial loads or rib and retail equipment bacterial loads, the following equation is recommended as the most useful predictor of case life: Steak case life (days) = 3.97 − 0.19 (log bacteria/cm^2 on wholesale ribs) − 0.14 (log bacteria/cm^2 on retail process-

Research Station, Lacombe, Alta.

ing equipment). This equation could also be used by the retailer to assess the quality of wholesale product received from different suppliers.

Meat quality

The efficacy of antioxidants for prolonging the frozen storability of dry-cured bacon slices. Methods for extending shelf life and keeping quality in fresh and cured meat products are currently the focus of general interest in the meat industry, and problems associated with unsatisfactory keeping quality constitute a main economic cost in both foreign and domestic markets. Results from experiments related to this problem conducted at the Lacombe Meat Research Centre indicated that the development of oxidative rancidity in bacon during frozen storage markedly reduces the shelf life of this cured pork cut. Consequently, it has been demonstrated that bacon cannot be stored in the frozen state beyond 112 days without losing its palatability. However, various antioxidants have been successfully utilized in the food industry to reduce the development of oxidative rancidity and thereby to extend the shelf life of various foods. A recent study at the Lacombe Research Station evaluated 15 different antioxidant combinations for their efficacy for extending the frozen storability of dry-cured bacon slices. The incorporation of ascorbic acid (vitamin C), butylated hydroxyanisol (BHA), butylated hydroxytoluene (BHT), and propyl gallate alone or in combination into a dry sugar bacon cure generally reduced rancidity development in bacon slices during prolonged frozen storage. However, the combination of BHA, BHT, and propyl gallate was the only antioxidant treatment that was effective for extending the frozen storability of bacon slices from the standpoint of flavor desirability and over all palatability. Bacon slices cured in the presence of this antioxidant combination remained acceptable to a consumer taste panel for up to 196 days or approximately 84 days longer, during frozen storage, than bacon cured in the absence of antioxidants.

CEREAL BREEDING, PATHOLOGY, AND FORAGES

Cereal pathology

Stem melanosis resistance of Park wheat related to soil copper deficiency. Stem melanosis of Park wheat, caused by the bacterium *Pseudomonas cichorii*, has recently become more widespread in the parklands of central and northern Alberta. Diseased wheat is generally found on sandy type soils. The application of dissolved copper chelate at 2.5 kg/ha to land in 1984 that had grown diseased Park wheat in the previous year resulted in almost totally disease-free Park wheat in 1984. The soils that grew the diseased wheat were deficient in copper and zinc. The addition of zinc to the soil promoted extensive plant growth but did not protect the plant from stem melanosis. The added copper not only promoted extensive plant growth but also caused Park wheat to be resistant to stem melanosis. Other hard red spring wheat cultivars are more tolerant than Park to low levels of soil copper, as they developed very few symptoms of head melanosis on the copper deficient soils.

Forage crops

Annual crops produce high yields of forage. The production of forage from annual crops has been examined for the past 5 yr at Lacombe. Several locations representing the black- and gray-wooded soils were used to determine the highest yielding crops and varieties. Oats were the best silage producer with an average dry matter yield of 8.1 t/ha. Sunflowers produced 7.2 t/ha, but the yields were highly variable at the different locations and from year to year. Triticale, a wheat–rye cross, averaged 6.6 t/ha and outyielded both wheat at 6.24 t/ha and spring rye at 5.9 t/ha. Corn, peas, and fababeans yielded 5.5, 5.1, and 5.0 t/ha, respectively; however, peas and fababeans produced more protein per hectare than any of the other crops. It was found that somewhat later seeding of the early maturing cereal crops resulted in increased yields. Crops grown for silage had to be harvested earlier if quality was to be maintained than when grown for grain. Forage yields were found to decrease when harvesting was delayed much beyond the soft dough stage of growth. Increased levels of nitrogen fertilizers enhanced the yields of oats and barley when grown for whole plant silage to a greater extent than when the two crops were grown for grain. Maximum forage yield for barley and oats was achieved with N fertilizer at 122 and 115 kg/ha, respectively whereas maximum grain production for barley and oats was achieved with N fertilizer at 92 and 85 kg/ha, respectively. Phosphorus, applied at the rate of 15 kg/ha, resulted in maximum barley forage and grain yield and maximum oat grain yield, whereas phosphorus applied at the rate of 20 kg/ha was required to achieve maximum yield of oat forage. The amount of protein in the forage was directly related to the amount of nitrogen applied to soils with low fertility. Protein in barley increased from 10.4% with no added nitrogen, to 14.5% with

nitrogen at 200 kg/ha, and in oats it increased from 5.1% to 9.8% with nitrogen at 200 kg/ha. Multiple forage harvests reduced yields from a single late harvest (silage). A two-cut system (hay) reduced yields to about 60%, and a multiple-cut system (3–6) (simulated pasture) reduced yields to about 30%. The spring cereals, as pasture, produced heavily in the spring, and then became relatively unproductive in the later part of the grazing season, whereas spring-planted winter cereals and Italian rye grass were not very productive in the spring but continued growth until fall.

CROP MANAGEMENT AND SOILS

Weed research

Tolerance of barley to trifluralin deep-incorporated. Field experiments were conducted to investigate the tolerance of Galt barley seeded 5 cm deep in a Ponoka loam soil treated with trifluralin. There were eight rates of application from 0 to 3 kg/ha applied in fall and spring and incorporated by means of a rototiller set to till to a depth of 10 cm. All data were analyzed by regression. Gas chromatographic analysis of extracts of soil samples collected in the spring following fall application of trifluralin (0.0 to 3.0 kg/ha) indicated that approximately 45% of the herbicide was lost regardless of rate applied. Fall application of trifluralin up to 3 kg/ha and spring application of trifluralin up to 1.1 kg/ha did not adversely affect the numbers of barley seedlings that emerged. Trifluralin treatments within the rate range 0.85 to 1.4 kg/ha caused severe early injury (delayed growth) to barley, the magnitude of which varied with the season and year of application. Fall application caused less early injury than the respective spring application during both years. With fall or spring applications up to 1.3 kg/ha and 1.0 kg/ha, respectively, barley yields were not reduced compared to the untreated control. With fall application at 1.4 kg/ha, barley yield was reduced in one of the 2 yr. Rates in excess of 1.8 kg/ha caused significant yield reductions with all treatments. The data indicate that trifluralin could be used as a deep-incorporated fall or spring treatment at rates up to 1.3 or 1.0 kg/ha, respectively, for weed control in barley in central Alberta. Fall application would improve the safety to the crop. Barley could also be seeded into soil where trifluralin (1.4 kg/ha) was applied as a fall treatment for weed control in rapeseed but some loss of yield could be expected.

Soil fertility

Fall versus spring soil sampling for soil test nitrogen fertilizer recommendations in central Alberta. Soil samples for fertilizer recommendations are normally taken by farmers in the fall. It was generally assumed that soil NO_3-N (crop available N) in the surface soil would not change considerably from fall to spring. Soil samples were taken from 100 stubble fields over 10 yr in central Alberta during fall and spring. On average, the soils increased in NO_3-N by 18 kg/ha between fall and spring. Of the total 100 tests, 20 tests showed an increase in NO_3-N from fall to spring ranging from 21 to 30 kg/ha and in 18 tests increases ranged from 31 to 51 kg/ha. Of the 18 high-accumulating tests, 16 were on Black soils. This suggested that for some soils the recommendations for fertilizer N will be too high when based on fall sampling. Regression analysis of the data indicated that soil NO_3-N in fall samplings was not as good a predictor of grain yield as the soil NO_3-N in spring soil samples.

In 26 field tests, the soils were sampled twice in fall (i.e., early fall–early October and late fall–early November) to find if late fall sampling can minimize errors in N fertilizer recommendations caused by soil sampling time. The soil NO_3-N increased from early fall to spring by 33 kg/ha, whereas the increase in soil NO_3-N from late fall to spring was only 15 kg/ha. Regression analysis of the data showed that soil NO_3-N in late fall samples predicted grain yields more accurately than soil NO_3-N in early fall samples. These results demonstrated that delaying soil sampling in fall reduced the soil NO_3-N gap between fall and spring samplings, and this may improve the accuracy of fertilizer N recommendations over early fall sampling.

SOILS AND CROPS SUBSTATION, VEGREVILLE

Soils

The effect of gypsum on growth and chemical composition of barley seedlings grown on a Solonetzic soil. Solonetzic soils present particular difficulties for plant growth and crop production. These soils are enriched in sodium and this results in poor soil physical structure as well as mineral nutrient imbalance in plants growing on them. A greenhouse study was established to investigate the magnitude of plant nutritional effects on the growth of barley seedlings, using the AP horizon of a Solonetzic soil. Two soil treatments were investigated: a Solonetzic soil

was compared to the same soil amended with calcium sulfate (gypsum). Single pre-germinated barley seedlings (*Hordeum vulgare* 'Bonanza') were transplanted into cylinders containing the soil treatments. Plants were watered with distilled water in small aliquots to prevent saturation of the soil and to prevent development of massive soil structure. All plants were harvested at the three-leaf stage, 20 days after transplanting. Samples were subsequently dried and analyzed for mineral nutrient accumulation.

Plant growth was approximately two times greater on the gypsum-amended soil for both plant shoots and roots. Reduced plant growth in the non-treated soil was associated with high concentration of sodium and low levels of potassium and calcium in both plant shoot and root tissues. Magnesium levels did not differ between treatments. Sodium accumulated in plant shoots with sodium concentration approximately five times greater in plant shoots than roots in those plants grown on the non-amended soil. This experiment demonstrated that plant growth and chemical composition are deleteriously affected by growth on Solonetzic soils, even in the absence of poor soil physical characteristics.

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Research Station, Lethbridge, Alberta

PROFESSIONAL STAFF

D.G. Dorrell, BSA, MSc, PhD	Director
E.E. Swierstra, BSA, MSA, PhD	Assistant Director
S.B. Arnason, BSA	Head, Administration
B.D. Clark	Administrative Officer, Finance and materiel management
M.J. McCormick, BA	Personnel Officer
W.H. Mains, MSA(Eng)	Facilities Management Engineer

Scientific Support

C.M. Cutler,[1] BA, MLS	Area Coordinator, Library
B.S. Freeze,[2] BSA, MSc	Bioeconomist
G.C. Kozub, BSc, MSc	Statistician
J.C.M. L'Arrivée, BSA, MSc, PhD	Technical Information Officer
C.M. Ronning Mains,[1] BA, BLS	Librarian
G.B. Schaalje, BS, MS	Statistician
L.J.L. Sears, BA	Scientific Editor

Animal Parasitology

W.O. Haufe, BA, MSc, DIC, PhD	Head of Section; Bioclimatology
R.W. Baron, BSc, PhD	Immunology
R.H. Robertson, BA, MSc	Serology
J.A. Shemanchuk, CD, BSc, MSc	Biting-fly ecology
J.L. Shipp, BSc, MSc, PhD	Black-fly ecology
W.G. Taylor, BSP, PhD	Pesticide chemistry
J. Weintraub, BA, MS	Cattle grub ecology

Animal Science

J.E.Lawson, BSA, MSA	Head of Section; Beef cattle breeding
D.R.C. Bailey, BSc, PhD	Beef cattle breeding
C.B.M. Bailey, BSA, MSA, PhD	Animal physiology
K.-J. Cheng, BSc, MSc, PhD	Rumen microbiology
G.H. Coulter, BSc, PhD	Reproductive physiology
G.A. Grigat, BSc, PhD	Animal nutrition
R. Hironaka, BSc, MSc, PhD	Animal nutrition
L.A. McClelland,[3] BSc, MSc	Sheep breeding
G.J. Mears, BSc, MSc, PhD	Animal physiology
R.C. Phillippe, BSc	Bacterial culture collection
J.A.P. Vesely, BSA, MSA, PhD	Sheep and dairy cattle breeding

Crop Entomology

D.L. Struble, BA, MA, PhD	Head of Section; Insect attractants
J.R. Byers, BSA, MSc, PhD	Cutworm ecology
W.A. Charnetski, BSc, MSc, PhD	Insecticides
A.M. Harper, BSc, MSc, PhD	Aphids
B.D. Hill, BSc, MSc, PhD	Residue chemistry

D.L. Johnson, BSc, MSc, PhD	Rangeland insects
K.W. Richards, BSc, MSc, PhD	Insect pollinators
B.D. Schaber, BSc, MSc, PhD	Forage crop pests
G.H. Whitfield, BSc, MSc, PhD	Potato and sugar beet pests

Plant Pathology

F.R. Harper, BSc, MSc, PhD	Head of Section; Cereal leaf diseases
R.L. Conner, BSA, PhD	Cereal diseases
D.A. Gaudet, BSc, MSc, PhD	Snow molds
H.-C. Huang, BSc, MSc, PhD	Forage and special crops diseases
G.A. Nelson, BSc, MSc, PhD	Potato and bacterial diseases
D.W.A. Roberts, BA, PhD	Cold-hardiness physiology

Plant Science

D.B. Wilson, BSc, MS, PhD	Head of Section; Irrigated pastures
J.R. Allan, BSc, MA, PhD	Aquatic plant physiology
R.E. Blackshaw,[4] BSc, MSc	Weed control
M.R. Hanna, BSA, MSA, PhD	Forage legume breeding
M.S. Kaldy, BSc, MS, PhD	Food science
G.A. Kemp, BSc, PhD	Vegetable breeding
D.R. Lynch, BSc, MSc, PhD	Potato breeding
M.D. MacDonald, BSc, PhD	Corn breeding
D.J. Major, BSc, MSc, PhD	Crop physiology
K.W. May, BSc, MSc, PhD	Barley breeding
R.J. Morrison, BSc, PhD	Spring wheat breeding
J.R. Moyer, BSc, MSc, PhD	Weed control
H.-H. Mundel, BSA, MS, PhD	New crops
S. Smoliak, FSRM, BSc, MS	Dryland pastures
J.B. Thomas, BSc, MSc, PhD	Winter and soft white spring wheat breeding
E.D.P. Whelan,[5] BSA, MSA, PhD	Wheat cytogenetics
W.D. Willms, BSF, MSc, PhD	Rangeland ecology

Soil Science

D.C. MacKay, FCSSS, BSc, MS, PhD	Head of Section; Plant nutrition
G.J. Beke, BSA, MSc, PhD	Hydrology
J.B. Bole, BSA, MSc, PhD	Plant nutrition
J.M. Carefoot,[6] BSA, MSA	Chemical analyses
C. Chang, BSc, MSc, PhD	Soil physics
J.F. Dormaar, BSA, MSA, PhD	Organic chemistry
N. Foroud, BSc, MSc, PhD	Irrigation engineering
B.W. Grace, BSc, MSc, PhD	Agrometeorology
H.H. Janzen, BSA, PhD	Dryland agronomy
R.M.N. Kucey, BSc, PhD	Soil fertility
C.W. Lindwall, BSc, MSc, PhD	Agricultural engineering
R.J. Rennie, BSA, MSc, PhD	Soil microbiology
T.G. Sommerfeldt, BSc, MS, PhD	Drainage engineering

Departures

S. Dubetz, BSc, MS Retired 21 September 1984	Irrigation agronomy
G.K. Honey, BSA Retired 13 July 1984	Technical Information Officer

M.A. Khan, GVSc, MS, PhD Retired 5 October 1984	Toxicology
R.B. Peveril, BSc Transferred to Information Systems Directorate, Veterans Affairs Canada, 30 March 1984	Computer System Manager
P.R. Wilkinson, BA, MA, PhD Retired 13 April 1984	Tick ecologist

VISITING SCIENTISTS

P.E.A. Asea, MSc International Atomic Energy Agency training fellow, July 1982 to November 1984	Plant nutrition
J. Chiquette, MSc Agriculture Canada Research Scientist training fellow, August 1984 to December 1986	Rumen microbiology
G.E.S. Diab, PhD Visiting Research Fellow, Canadian International Development Research Centre, April 1983 to March 1984	Soil fertility
M. Elegba, Dip. C & G International Atomic Energy Agency training fellow, April 1983 to March 1984	Nitrogen fixation
D.K. Jain, PhD National Sciences and Engineering Research Council postdoctorate fellow, September 1984 to September 1986	Nitrogen fixation
H. Kudo, DVM, MVS, PhD Postdoctorate fellow, September 1981 to September 1985	Rumen microbiology
W.S. Procunier, PhD Postdoctorate fellow, May 1982 to January 1984	Cytogenetics
P.J. Scholl, PhD Seconded from U.S. Department of Agriculture to the Canada/USA sterile insect release project on warble flies, March 1982 to February 1987	Integrated pest management and warble fly ecology

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[1]Seconded from Libraries Division, Finance and Administration Branch.
[2]On educational leave, Oregon State University, September 1984 to August 1987.
[3]On educational leave, Massey University, Palmerston North, New Zealand, January 1984 to July 1986.
[4]On educational leave, University of Guelph, January 1983 to January 1986.
[5]On transfer of work, Grasslands Division, Department of Scientific and Industrial Research, Palmerston North, New Zealand, September 1984 to September 1985.
[6]On educational leave, University of Alberta, September 1982 to August 1985.

INTRODUCTION

The Research Station at Lethbridge, in southern Alberta, is located at the center of one of the most diverse agricultural regions in Canada. A wide variety of crops is grown on both dry and irrigated land, and a major part of Canada's beef cattle industry is established on the farms and ranches within and around the region.

Station scientists conduct fundamental and applied research in six disciplines to support 13 Research Branch objectives. In addition to the 500-ha site at Lethbridge, the station conducts research at a 17 000-ha ranch and beef cattle breeding station near Manyberries, a 400-ha ranch near Stavely in the foothills of the Rocky Mountains, and a 130-ha irrigation substation at Vauxhall. Crop production and improvement research deals with the breeding and genetics of 12 different species or crop kinds, the study of the biology and control of a wide range of plant diseases and insect pests, and the development of improved agronomic practices related to soil fertility, tillage, and water use. Related studies on physical, chemical, microbiological, and hydrological aspects of soil provide guidance for the introduction of methods to maintain or improve the soil resource.

Livestock research is concerned with evaluating the effects of breed or selection methods on the improvement of beef or dairy cattle, and breed and management on sheep productivity. Other studies on nutrition and physiology contribute to the development of efficient methods of beef cattle production. The station is also a major center for the study of arthropod pests of livestock.

During 1984, Dr. P.R. Wilkinson, Tick Ecologist; Mr. S. Dubetz, Irrigation Agronomist; Dr. M.A. Khan, Animal Toxicologist; Mr. G.K. Honey, Information Officer; and Mr. C.G. Schoening, Finance Officer, retired after long and productive careers. Dr. E.E. Swierstra was named Assistant Director; Dr. D.B. Wilson, who had been Acting Assistant Director, returned to his position as Head, Plant Science Section; and Mr. S. Smoliak, who had been Acting Head of Plant Science, returned to his research program. Dr. D.L. Struble was named Head, Crop Entomology Section; and Mr. J.E. Lawson was named Head, Animal Science Section. Two new scientists were appointed, Dr. H.H. Janzen in dryland agronomy and Dr. D.R.C. Bailey in beef breeding and genetics. Dr. J.C.M. L'Arrivée was named Technical Information Officer and Mr. B.D. Clark as Administrative Officer, Finance and Materiel Management. Our scientists were actively involved in organizing the Canadian Soil Science Society Annual Meeting and the International Symposium on Ruminant Physiology and Nutrition, both held in Banff, and they hosted the Joint Meeting of the National Alfalfa Improvement Conference and the Forage Insect Workers Conference. We were involved in numerous international exchanges and visits and entered into a contract with the International Development Research Centre to lead a project in dinitrogen fixation in Thailand. Twelve research projects were partially funded by the Government of Alberta through the Farming for the Future programs.

The short reports that follow give results of some recent research and illustrate the types of studies that are under way. Further information may be obtained from publications listed at the end of the report or from scientists. Correspondence or requests for reprints should be addressed to the Research Station, Agriculture Canada, Lethbridge, Alta. T1J 4B1.

D.G. Dorrell
Director

ANIMAL PARASITOLOGY

Biting flies

Repellents. A detailed investigation to clarify the molecular structure of R-69 insect repellent (Citronyl™, S.C. Johnson and Son) showed that this registered product was a mixture of four closely related organic (oxazolidine) compounds. Each isomeric component was separated by high-pressure liquid chromatography and ultimately isolated in purified form. The proton-decoupled, natural-abundance, ^{13}C nuclear magnetic resonance (NMR) spectrum of each purified sample was recorded in benzene and chloroform solutions at various temperatures. Interpretation of the spectra was possible by comparisons with the ^{13}C NMR spectra of similar compounds and by special NMR experiments. The interpreted NMR spectra provided unambiguous evidence on the chemical identity of the four components comprising this insect repellent. Isolation and identification of these compounds is essential to evaluate their individual properties and to learn

why this chemical and related oxazolidines repel biting insects.

Horn fly control and productivity of cattle. Strategies to maximize benefits from pest control practices have been defined and verified through a combination of experimental modeling and pest control studies on irrigated pastures and cattle ranges. On irrigated pastures, a complex interaction exists between horn flies and cattle involving behavioral, neurosensory, and immunosensory systems of the host. The host systems are mediated in grazing cattle at two biological levels: a physiological one in individual animals, and an ecological one, which governs behavioral patterns in social units or populations of animals. Since the host systems respond to different thresholds of intensity of attack and blood feeding by pests, the impacts of infestations vary widely with developmental status and nutritional state of cattle and with conditions of their grazing environment.

Mediation of host responses during infestations of horn flies is determined by contrasting thresholds that are very low for ecological levels and comparatively high for physiological levels of impact on growth and maintenance of cattle. This contrast, interpreted through large-scale range experiments and farm-level simulation approaches, is a significant factor in designing a pest control strategy and in identifying the optimum control practices for economic benefits in efficiency of production. The difference between eradication and reduction of pest populations can amount to 16% of the potential growth rate of animals responding to various grazing conditions. Thus, the choice of either eradicating or reducing pest populations as strategies in pest management depends on the economic significance of this difference in productivity in comparison with the costs of options available for livestock pest control. The understanding and economic quantification of these host–parasite relations greatly improve our capability to evaluate the merits of expensive eradication and integrated management procedures against current conventional practices of population reduction such as use of toxic chemical pesticides.

Effect of microclimate on flight activity. The need to predict optimal weather conditions for flight activity of black flies has been recognized, to improve the timing of on-farm chemical treatments. The effect of microclimate on the flight activity of a black fly species, *Simulium arcticum* Malloch, was investigated for a pasture situation in central Alberta. No one weather variable influenced flight activity all the time; rather, the combined influence of all variables affected black fly activity. Vapor pressure, light intensity, air temperature, and wind gust velocity were the most important weather variables affecting flight activity of *S. arcticum*, with vapor pressure having the greatest effect on hourly flight activity. Now, laboratory studies will be conducted to determine more precisely the relationship between flight activity and each weather variable.

Warble grubs

Integrated pest management for eradication of Hypoderma lineatum and H. bovis. A Canada–USA project, begun in 1982 to evaluate integrated management of cattle grubs, has demonstrated the effects of using insecticides before integration with sterile warble fly releases. On both sides of the Alberta/Montana border, grub populations in cattle have approached equilibrium at low levels as a result of organized insecticidal treatments. About 6.6% of cattle on the Canadian side and 2.6% on the American side remained infested at low numbers of grubs per animal. These differences may reflect different approaches in treatment: by owners under enabling legislation in Alberta, and by project staff in Montana. Samples of untreated ranch cattle, which were monitored yearly for residual grub infestations, demonstrated that the populations rebounded from the treatments to infest about 60 to 70% of young stock. Infestation rates ranged from 20 to 100% of cattle from the various monitored ranches at relatively low grub densities corresponding to the prevalence of infestation.

Releases of sterile warble flies were undertaken to initiate the second phase of the project by experimental comparisons of localized inundation with grid-pattern releases. The results will be analyzed to determine the preferred release strategy when the surviving grub populations can be assessed in the spring of 1985. In preparation for full-scale sterile fly releases in 1985, several technical modifications were introduced to improve the number and vigor of sterile flies and to deploy the releases more effectively. To provide a basis for economic evaluation of cattle grub control, an experiment was initiated to determine relationships between infestation levels and performance characteristics of host cattle from weaning to slaughter. Ancillary research has been conducted in cooperation with serologists to determine the possibility of early quantitative identification of infested cattle by measurement of antibody titers. Other cooperative work included evaluation of the efficacy of late-season treatments with the new systemic insecticide Ivermectin to determine the feasibility of controlling grubs that survive the regular fall treatment and are detected in spring inspections.

Research Station, Lethbridge, Alta.

ANIMAL SCIENCE

Beef cattle

Degradation of nitrate, nitrite, and nitrotoxins. Nitrate, given intraruminally (0.1 g NO_3 per kilogram of body weight) to cattle, stimulated the capacity of the rumen microflora to degrade nitrite (NO_2) and nitrate. Three- to four-fold increases in rates of NO_2 and NO_3 reduction were observed during NO_3 treatment. The treatment also appeared to stimulate nitropropanol degradation but this effect was less pronounced. The enhanced capacity of rumen microbes to degrade NO_2 and NO_3 was transferred to non-induced (untreated) animals housed in adjacent pens. The transfer of induced metabolism was not observed when induced animals were widely separated (0.5 km) from the non-induced ones. This discovery raised the disquieting possibility that control groups of test animals may only function as true control populations if they are significantly separated from the treated animals to preclude microbiological cross-contamination.

Rumen microbiology. A technique has been developed whereby intracellular urease activity of a ruminal bacterium can be identified by transmission electron microscopy. The ammonium produced from the enzymatic hydrolysis of urea is first precipitated with sodium tetraphenylboron and then replaced with silver to produce electron-dense silver tetraphenylboron. This direct reaction product deposition procedure was used to demonstrate the presence of membrane-bound urease of *Staphylococcus* sp., strain H3-22, a gram-positive ruminal bacterium. This new method for the histochemical localization of ammonia production in biological systems lends itself nicely to such diverse areas as the study of ammonia generated in the rumen by urease or deaminase and the study of symbiotic nitrogen fixation in legumes. In the medical field, it may prove to be quite useful in illustrating pathogenic and enzymatic mechanisms involved in struvite stone production in the kidney.

Ammonia treatment of straw. Pretreatment of straw with anhydrous ammonia increased its susceptibility to dissolution by the predominant cellulolytic bacteria from the rumen, *Bacteroides succinogenes*, *Ruminococcus albus*, and *Ruminococcus flavefaciens*. Ammonia treatment also increased the production of microbial protein and fermentation products by all three species. Scanning electron microscope observations of straw during digestion showed that the attack on straw by these bacteria was accompanied by the formation of substantial adherent microcolonies, which appeared to be important for the digestion of celluiose.

Sheep

Crossbred performance. Ewe lambs of eight crosses (Dorset × 3/4 Dorset, DD; Dorset × 3/4 Finn, DF; Finn × 3/4 Dorset, FD; Finn × 3/4 Finn, FF; Romanov × 3/4 Dorset, RD; Romanov × 3/4 Finn, RF; Romanov × Western, RW; Western × Western, WW) were compared for age and weight at conception, conception rates, ovulation rates, litter size, and prenatal mortality. Age at conception in days, ovulation rate, and litter size for the eight groups were as follows: DD, 236 ± 5, 1.5 ± 0.1, 1.3 ± 0.2; DF, 218 ± 4, 1.5 ± 0.1, 1.4 ± 0.1; FD, 234 ± 5, 2.2. ± 0.1, 1.8 ± 0.1; FF, 228 ± 4, 2.6 ± 0.1, 2.3 ± 0.1; RD, 209 ± 5, 2.2 ± 0.2, 2.0 ± 0.2; RF, 213 ± 3, 2.7 ± 0.1, 2.4 ± 0.1; RW, 222 ± 5, 2.1 ± 0.2, 2.1 ± 0.2; WW, 247 ± 5, 1.0 ± 0.1, 1.0 ± 0.2. Lambs sired by Romanov rams conceived at an earlier age (210 ± 3 days) than those sired by Dorset and Finn rams (226 ± 3 and 230 ± 3 days). Prenatal mortality was a function of length of pregnancy and ovulation rate. Lambs ovulating 1, 2, 3, and 4 ova had a prenatal mortality of 0, 25, 33, and 47%. It was concluded that Romanov crosses were similar to Finn crosses in ovulation rate and litter size, but the Romanov crosses conceived at an earlier age than the Finn crosses.

Ruminal digestion of alfalfa. A feeding trial, using six fistulated sheep, was conducted to evaluate two strains of alfalfa that were selected for slow and fast initial rates of digestion (IRD). To determine how these strains affect rumen metabolism, samples of rumen fluid were collected before feeding, as well as 2 h and 4 h after feeding. Concentrations of soluble protein, soluble carbohydrates, chlorophyll, volatile fatty acids, and hydrogen ions were significantly lower in rumen fluid from sheep fed slow-IRD alfalfa than in sheep fed fast-IRD alfalfa. These results show that the bloat-causing potential of alfalfa might be reduced through further breeding for slow-IRD alfalfa strains.

CROP ENTOMOLOGY

Grasshoppers

Population studies. Since annual surveys began in 1932, there have been five major grasshopper outbreaks in Alberta. The sixth major outbreak began in 1983 and continued in 1984. Large areas of the municipalities of Warner, Lethbridge, Willow Creek, and Wheat-

land are rated severe to very severe for 1985. Dry conditions and high temperatures in 1984 promoted excellent survival rates and rapid growth of grasshoppers. Despite poor food quality in August and cool wet weather in early September, large numbers of eggs were laid by the very large breeding populations in some areas. Particularly hard hit were areas that had severe grasshopper problems in 1983 and received only one-half to three-quarters of the normal rainfall during the 1984 growing season.

Areas north of Drumheller are generally rated very light to light for the coming year, with only 8% of the area north of the 52°N latitude rated moderate. In 1984, this region received normal or above-normal rainfall, which reduced grasshopper populations. No severe outbreaks are expected for agricultural land north of Drumheller, although warm dry weather could lead to moderate grasshopper problems in the Wainwright–Provost area.

The most common species threatening cereal crops were the lesser migratory grasshopper, the twostriped grasshopper, and the clearwinged grasshopper. The last two species increased dramatically in the southern counties over the past 2 yr. The white whiskers grasshopper, the infant grasshopper, and the Packard grasshopper were common on rangeland and pasture.

Cutworms

Population monitoring. Population levels of seven species of cutworm moths were monitored in southern Alberta with sex-attractant traps for the seventh consecutive year. Catches of clover cutworm, variegated cutworm, and bertha armyworm moths were 78, 52, and 7% lower, respectively, than in 1983. Catches of pale western, redbacked, darksided, and army cutworm moths were 36, 52, 37, and 133% higher than in 1983. The relationship between moth catches and risk of subsequent larval infestations continued to be encouraging. Infestations of pale western cutworm in the spring of 1984 were the most severe in 20 yr. The likelihood of an outbreak and the localities where infestations would be most severe were accurately predicted by the monitoring program. Within the 13 000 km^2 survey area, 20 000 ha of cereal crops were treated with insecticide and 1500 ha were reseeded.

The threshold level for pale western cutworm, with the sex-attractant traps currently used, is 250 to 300 moths per trap. Above this level, larval infestations are likely to occur in susceptible fields the following spring, particularly if the weather is warm and dry. In 1983, catches of pale western cutworm moths exceeded 300 per trap at nine of the 81 survey locations and none exceeded 400 per trap. In 1984, catches exceeded 300 per trap at 25 of the 81 locations and, of these, eight exceeded 400 per trap and two exceeded 500 per trap. The weather conditions in August and September of 1984 were favorable for oviposition, so clearly there is potential for more severe and widespread infestations in the spring of 1985.

Special crop pests

About 15% of the mustard seed and a small amount of the canola produced in Alberta in 1983 were contaminated by excessive levels of insect excreta. The frass pellets responsible were produced by caterpillars of the painted lady butterfly, which sporadically becomes abundant as a result of migration from the southwestern USA. The painted lady caterpillar builds an inconspicuous nest by folding or tying the leaves of its food plant together with silk. Frass pellets produced by the caterpillars are retained in the nest and, under certain conditions, such as early harvest or absence of rain, may persist until the crop is combined. The preferred food plant is Canada thistle and most infestations in affected fields probably originated in patches of this weed.

Losses due to downgrading of mustard seed or costs of additional cleaning and associated wastage amounted to $100/ha in some fields.

Alfalfa leafcutter bees

Diseases. The chalkbrood fungus, *Ascosphaera aggregata* Skou, a serious disease of alfalfa leafcutter bees in the United States, was found in 1982 in 0.16% of 49 901 cells examined from 80 samples of bees from across western Canada. The disease was found only in Manitoba samples and represents the first record of this disease in Canada. In 1983, this fungus was again found in samples from the same beekeepers at about the same level of infestation. The fungus was also found at low levels of incidence in 1983 in Alberta samples submitted to the Canadian Leafcutter Bee Cocoon Testing Centre, Brooks, Alta. This disease is not expected to become as severe in Canada as it is in the United States because of the universal use in Canada of the loose-cell system of bee management; an almost univoltine population of bees; a small feral population of bees that survives the winter and which could act as a reservoir of the disease; and the possibility that environmental conditions in western Canada are not conducive to infestation by chalkbrood.

Row crop pests

The sugarbeet root maggot is a major pest of sugarbeets in Alberta, Manitoba, and the western United States. A degree-day model for predicting

the emergence of this pest was developed from laboratory and field studies. Survival rates of the overwintering larvae were described for various constant temperatures and a developmental base temperature of 8.6°C was determined. Field cages were used to monitor adult root maggot emergence in former sugarbeet fields, and maximum and minimum air temperatures were used to obtain degree-day accumulations. Prediction of sugarbeet root maggot emergence in the spring was greatly improved using a degree-day model over the historical use of calendar dates. Time of 50% emergence occurred at ca. 200 degree days. Accurate prediction of sugarbeet root maggot emergence will allow growers to monitor their fields and apply postemergence insecticides at the optimum time for control, in areas where root maggot damage is imminent.

The European corn borer population continued to increase in the Medicine Hat–Bow Island area and the population level was about four times that of 1983, based on pheromone trap catches. Several fresh-market sweet-corn growers sprayed for larval control. There was no spraying of field corn and there were minimal losses in fields of silage and grain corn.

Forage crop pests

Alfalfa weevil population levels have increased dramatically this season. Several seed alfalfa fields not in the pest management program were cut for hay and about 85% of the seed fields within the program were sprayed for weevil control. During the past 2 yr, the alfalfa root curculio has invaded some of the cicer milkvetch fields in southern Alberta. This new pest of cicer milkvetch feeds on the new shoots in the spring, which results in a significant reduction in crop yield.

PLANT PATHOLOGY

Wheat

Vernalization and cold-hardiness of wheat. In the autumn, winter wheats in the field develop cold-hardiness at the same time that they vernalize or develop the ability to head rapidly and uniformly the following season.

Various temperature regimes have been tested to identify conditions that will separate these two processes in time. Temperatures alternating daily between 2°C and 35°C give best separation, because they delay vernalization but not cold-hardening. This method for separating these two processes will be useful to persons working on the biochemistry of either process. That vernalization develops as rapidly at temperatures between 2°C and 20°C as at a constant 2°C explains why winter wheat that fails to germinate in the autumn will vernalize in the spring and produce a good crop if the stand is adequate and other conditions are favorable.

Cereal diseases

Black point. Black point is a major cause of downgrading of soft white spring wheat in western Canada. Recent field studies have demonstrated differences in black point severity among lines of soft white spring wheat. In a study to develop a reliable method for screening lines for black point resistance under controlled conditions, several inoculation techniques were compared, using an isolate of *Alternaria alternata*. Needle inoculation of the florets or vacuum infiltration of the spike provided the most reliable means for screening for resistance. Treatments such as spraying the spikes or dipping them in inoculum produced low, inconsistent results that were unsuitable for the identification of resistant lines.

Cottony snow mold. Cottony snow mold is a serious disease of overwintering wheat and grasses in regions where snow cover persists throughout the winter. A technique that makes use of the great depth of focus and high resolution of scanning electron microscopy and simple preparation techniques of serial sectioning of paraffin-embedded plant tissue was developed to investigate infection of winter wheat leaves by the fungus that causes the disease. Penetration occurred exclusively through the stomata. Mycelial aggregates formed over the stomata before hyphae invaded surrounding leaf tissues. Spread of the pathogen within the leaf tissues coincided with the collapse of the cell walls and disorganization of cell constituents. Microsclerotia-like bodies formed in leaf tissues as early as 3 wk after inoculation. These bodies may serve as survival structures for strains of cottony snow mold fungus for which survival structures have not been reported.

Forage crop diseases

Transmission of verticillium wilt by alfalfa seed. The investigation on mechanisms of transmission of *Verticillium albo-atrum* indicates that the pathogen can be seed-borne in alfalfa plants through root-inoculation or via inoculated flowers. The frequency of *V. albo-atrum*-contaminated seeds from root-inoculated plants of different alfalfa varieties ranged from 0% in Vela to 5% in Anchor. Although the pathogen was present throughout the stems, it occurred only

sporadically in peduncles, pedicels, pods, and seeds.

Inoculation of the pathogen on flowers of healthy alfalfa plants variety Vernal showed that the pathogen readily infected the stigma and style. The fungus appeared to be latent in the style during all stages of seed development. However, under humid conditions, the fungus in the stylar tissue of a mature seed pod was able to colonize the pod and seed coat.

Insect transmission of Verticillium albo-atrum. Recent studies show that leaf-chewing insects such as grasshoppers and alfalfa weevils can transmit verticillium wilt of alfalfa via their feces. This suggests that the fungal pathogen can survive in the insect digestive tract. The pathogen usually appeared in the feces 1 day after the insects began feeding on diseased alfalfa leaves. The percentage of feces contaminated by the pathogen increased with the duration of feeding on diseased tissues. Alfalfa plants inoculated with grasshopper feces contaminated with the pathogen developed symptoms of verticillium wilt within 4–6 wk after inoculation. The study suggests that control of pest insects is required to prevent the spread of verticillium wilt in alfalfa fields.

Field crop diseases

Sclerotinia diseases. Sclerotia of *Sclerotinia sclerotiorum* collected from sunflower, safflower, mung bean, and bean in western Canada differed in their ability to germinate myceliogenically without added exogenous nutrients. The ability to germinate in this manner resulted from incomplete melanization of the rind of the sclerotium. Germination on autoclaved, moist soil occurred readily with intact, light-colored sclerotia but only when the rind was injured with black sclerotia. In addition, incompletely melanized, light-colored sclerotia were more frequently contaminated by microorganisms than were the uniformly melanized ones. Melanization of the rind is evidently important to the manner of germination and possibly to the survival of sclerotia of *S. sclerotiorum*.

PLANT SCIENCE

Potatoes

Potato yield testing. A modified augmented design to assess yield potential of tubers at an early stage in potato breeding was evaluated. The large number of lines to be tested, together with the small amount of tuber material of each line available at this stage in the program, precludes the use of standard statistical designs. In the augmented design, control varieties available in quantities that allow replication are randomized to a set of whole plots laid out in a latin square design. Each whole plot consists of nine subplots in a three by three arrangement. The control variety for each whole plot is planted in the center subplot so that the eight surrounding subplots in which test lines are planted are approximately equidistant from the control variety. Adjustments to the test lines can thus be made based on trends detected in the control plots. Data from the study indicate that this design provides a useful means of assessing gross genotypic potential of large populations of breeding material. The design was easy to lay out, manage, and harvest. Important changes in the ranking of seedlings for total tuber yield occurred at three of the four trial sites where control plot data were used to adjust the yield of test lines.

Field crops

Processing quality of beans. Some dry beans retain their shape when canned and may even be hard to cook, whereas others become extremely soft and mat in the can. In a series of tests, 38% of the beans in a can matted where the tendency to mat was high and only 10% of the beans matted where the tendency was low. The beans that matted excessively had a lower alcohol-insoluble solids content, 21%, than those with minimal matting characteristics, 24%. Other research has shown that alcohol-insoluble solids (starch, protein, fiber, hemicellulose) increase with maturity, suggesting that beans lacking maturity have a greater tendency to mat. Electron microscopy showed that matted beans had a less stable cell structure, which allowed the cell contents to diffuse under the high temperatures necessary for processing in the can. These results could explain the differences in texture of canned beans. In some seasons, a bean cultivar might not reach complete physiological maturity before frost and, even though the seeds appear to be ripe, the cell structure might be weak. The same cultivar would present no problem in a longer growing season.

Oilseed crops

CO_2 assimilation in rape. Changes in photosynthate source-sink relationships during the development of rapeseed growing under field conditions were investigated using $^{14}CO_2$. At flowering, leaves and stems were the principal sites of assimilation, taking up 46% and 41% of the $^{14}CO_2$, whereas pods took up only about 5%. Roots, pods, and later, seeds were sinks for photosynthates produced at flowering. At the onset of pod fill, leaves, stems, and pods took up 19, 43,

and 32%, respectively. Seeds were principal sinks during pod fill and ripening. These findings explain many of the apparent inconsistencies in the literature regarding the role of shoot parts in carbon nourishment of the seeds. As rape plants develop, the leaves, stems, and pods are the principal sites of CO_2 assimilation. Photosynthates produced from all three parts are translocated to the developing seeds. The amount of ^{14}C-labeled assimilates found in the seed was linearly related to the dry weight of the seed.

Safflower resistance to head rot. Safflower lines were screened in field experiments for resistance to head rot caused by *Sclerotinia sclerotiorum* (Lib.) de Bary. Plots were artificially infested with sclerotia at seeding and irrigated during the growing season to maintain adequate moisture for the production of mushrooms from the sclerotia. Spores produced from these mushrooms infected the safflower heads. The reaction of each line was similar over the 3 yr of testing. Severity of head rot varied significantly among the 20 lines tested. In a 1984 test, three cultivars from the United States, S-208, S-541, and Hartman, had 41, 30, and 20% infected heads. In the same year, the high-yielding, early maturing Lethbridge selection Lesaf 34C-OO had less than 9% infected heads. Level of resistance was not related to earliness of the lines. Yield losses ranged from as low as 10 kg/ha for Lesaf 34C-OO to around 1000 kg/ha for the most susceptible lines. The study demonstrated the possibility of developing early maturing safflower lines resistant to sclerotinia head rot for production on the Canadian prairies.

Cereal crops

Free amino acids in cold-hardened winter wheat. The free amino acids proline and glutamic acid increased in the crown of winter wheat in all treatments when exposed to cold-hardening. Glutamine also increased except when 90-80 N-P fertilizer was applied. The increase of proline and glutamic acid was enhanced with the application of P but counteracted by N. This enhancement was smaller with glutamine. The decrease of threonine, tyrosine, phenylalanine, lysine, and γ-aminobutyric acid with cold-hardening was not counteracted by application of N and P. However, isoleucine in cold-hardened winter wheat increased with the application of 180-0 fertilizer, and aspartic acid increased when P was added. The increase in alanine with cold-hardening was enhanced by P alone but counteracted by N-P treatments. The marked increase of proline during cold-hardening could be useful in the detection of cold-hardiness in winter wheats.

Owens soft white spring wheat. In years in which stripe rust is severe in the Pacific Northwest, soft white spring wheat growers in southeastern Alberta are also at risk from this disease. This is because the current variety, Fielder, is rust-susceptible. To cover this risk, a temporary license was granted to the resistant U.S. variety, Owens. Unfortunately, Owens represents a potential identification problem, since its kernel shape resembles that of a projected class of white, medium hard spring wheats (White Triple M) that is under development. This means the license for Owens will have to be withdrawn when the first White Triple M wheats enter cultivation. At that time, we hope to have a more suitable replacement available.

Apart from its disease resistance, Owens is more shatter-resistant and has better baking qualities than Fielder. Depending on the soil, Owens has yielded both more and less than Fielder, but outyields Fielder where stripe rust is heavy. On the negative side, its kernels are less attractive than Fielder. Owens is recommended only to those growers who need protection from stripe rust.

Cereal plot testing. Ten genotypes each of barley and wheat were grown in separate experiments with four types of plot borders to study the influence of plot borders on the ranking of grain yield of the cereals. The barley plots were established on dryland and the wheat on dryland and irrigated sites. Plot borders were (*1*) normal—six rows planted and the outside rows removed before harvest; (*2*) unbordered—four rows planted and two empty rows on each side of the plot; (*3*) winter wheat—four rows planted with the test genotype and the outside rows planted to winter wheat; (*4*) spring cereal—four rows of the test genotype bordered by one row of the alternate spring cereal (barley or wheat).

A significantly greater grain yield was obtained from unbordered or winter wheat-bordered plots than from the normally bordered plots in most comparisons. There were no significant interactions between barley genotypes and plot borders. A small interaction was detected between wheat genotypes and plot borders in some of the tests, but detailed statistical investigation revealed no single source for the interaction. It was concluded that the type of plot border for barley and wheat plots is of relatively little importance when the trial is being used mainly for comparative yield purposes.

Persistence of paraquat in soil. Seventy-four percent of the paraquat applied to a Lethbridge clay loam soil during an 8-yr minimum-tillage experiment remained in the soil at the end of the

experiment. To determine the capacity of the Lethbridge soil to inactivate paraquat, applications equivalent to a maximum of 3000 kg/ha were made in growth chamber and field experiments. In the growth chamber and in the field, more than 600 and 1000 kg/ha, respectively, of paraquat in one application were required to reduce wheat growth by 10%. Paraquat residue levels in the field soil did not decrease after the first summer. Paraquat residue was not found in wheat grain growing in soil with paraquat at 1650 kg/ha in the 0–15 cm layer. Paraquat could likely be applied for several hundred years at currently recommended rates for weed control on chemical fallow and not exceed the ability of Canadian prairie soils to inactivate it.

Forage crops

Long-term production of seeded pasture. Crested wheat grass and Russian wild rye pastures produce more forage than native rangeland, and therefore can be stocked more heavily. Over a 25-yr period, forage production on crested wheat grass and Russian wild rye pastures averaged 872 kg/ha and 601 kg/ha (dry weight basis), respectively, compared with 410 kg/ha on native range. Forage production from crested wheat grass and native range pastures was closely correlated with precipitation during April. Russian wild rye production was more closely related to June precipitation. Production on all three pasture types was also heavily influenced by the total seasonal (April to July) precipitation. Grazing studies conducted on these pastures, located at the Manyberries Research Substation, have shown that they can be grazed three to six times as heavily as native range. The heavier rate of grazing was possible on widely spaced rows, especially on fields of Russian wild rye.

Verticillium wilt resistance in alfalfa. Resistant varieties offer the best defense against verticillium wilt disease. An experimental synthetic (VW-33-2) developed at Lethbridge had the highest level of resistance to verticillium wilt among 31 varieties and strains that were included in two disease screening trials. VW-33-2 averaged 63% resistant plants in the two trials; the other 30 entries, all from the United States or Europe and all reported to have some level of resistance, averaged 27% resistant plants, with a range from 4 to 61%. VW-33-2 also has excellent resistance to bacterial wilt, comparable to that of Beaver. It is currently being tested in forage yield trials in those parts of Canada (British Columbia, Alberta, and Ontario) where the verticillium wilt problem is severe. If VW-33-2 is licensed as a new variety, seed could be made available to Canadian forage producers as early as 1988.

Stocking rates on native grassland. The effects of four stocking rates, 1.2, 1.6, 2.4, and 4.8 animal unit months per hectare (AUM/ha) on cattle production were examined over a 35-yr period on a rough fescue grassland. Forage productivity was reduced at the higher stocking rates. This resulted in a shortened grazing season in the field stocked at 4.8 AUM/ha. Although individual animal weights decreased with increased stocking rate, cattle gains per unit area increased. Average daily gain of cows was greatest in May but declined to become a loss in September. Calves showed maximum gains from June to July and never lost weight. Stocking rate affected the relative magnitude of average daily gain as well as the trend over the grazing season.

SOIL SCIENCE

Soil management and conservation

Zero tillage soil management. Zero tillage and conventional tillage systems were compared in both continuous cropping and crop–fallow rotations at six locations in southern Alberta for 5 yr. Tillage treatment had little effect on soil moisture or on bulk density of soil. High-clearance hoe drills with narrow furrow openers provided more effective seed placement than did triple-disc drills under no-till conditions. Over all, yields from recropped plots were 82% of those from fallowed plots. Generally, yields from no-till stubble crops were equal to those on conventionally tilled stubble but the yields from tilled fallows were often greater than those from chemical fallows. Lower yields from chemical summerfallow at some locations were attributed to weed competition or lower nitrate–nitrogen levels. In general, yield response to nitrogen fertilizer was greater on no-till fields than on conventionally tilled fields. No-till showed the greatest potential in recropped rotations, provided that weeds were controlled economically and effective seed and fertilizer placement was achieved with existing seed drills.

Soil management in accordance with spring moisture reserves. A model for use with a personal computer was developed at Lethbridge to allow extension personnel, producers, and agronomists in the fertilizer industry to make cropping decisions for barley production. The model uses the available spring-moisture reserve to estimate the return from fallowing or recropping as a function of rainfall probability. It also predicts optimum nitrogen fertilizer rates based on soil test nitrate–nitrogen, moisture supply, and economic variables. Using regression response

curves based on our research and current economic prices, an economic analysis was conducted on 200 random "years" of available spring water and growing season precipitation. A flexible cropping system, where half the land was fallowed in years when moisture reserves were low but all the land was cropped when reserves were adequate (> 79.5 mm), produced an average of $14.33/ha more than continuous barley and $22.08/ha more than a barley–fallow rotation. Although income variability was much greater than with a barley–fallow rotation, it was less than with a continuous cropping regime.

Restoring productivity of eroded soils. In 1957, a field was artificially eroded and then continuously cropped to barley for 7 yr. A wheat–fallow rotation that included four fertilizer treatments and green manure was maintained from 1965 to 1979. There was little evidence that the N, P, or C levels in the soil increased as a result of cropping or fertilizer treatment. Although green-manuring improved soil structure, wheat yields were not improved because of crop competition and poorer weed control in this part of the rotation. The addition of 45 kg N plus 90 kg P_2O_5 per hectare in each crop year to soils that had 8-10, 10-20, or > 46 cm of topsoil removed resulted in yield increases of 18, 46, and 71%, respectively, over the unfertilized check of each "erosion" treatment; however, the average yields were only 104, 91, and 70%, respectively, of the undisturbed, unfertilized (check) treatment. On soil where only 8–10 cm of topsoil were removed, treatments of 45 kg N plus 22 kg P_2O_5 per hectare were sufficient to restore the productivity with no benefit from additional phosphate. Precipitation had a greater effect than did fertilizer application on wheat yields. The loss of organic matter and associated soil structure characteristics seemed to be critical factors contributing to yield losses associated with soil erosion.

Burning of alfalfa stubble to control insects. Southern Alberta growers often burn fields of seed alfalfa prior to initiation of growth in the spring as part of an Integrated Pest Management Program. A single burn of the standing dead growth and debris of a 4-yr-old alfalfa crop led to significant increases in organic matter, nitrate-N, ammonium-N, available P, extractable K, electrical conductivity, and pH levels immediately after the fire. The lack of a measurable increase in water repellency of the soil indicated that the soil temperature at the time of burning did not exceed 150°C. The only measurable impact 1 yr later was the higher ($P < 0.05$) organic matter but after 2 yr there were no differences in any soil properties determined. The results of the study cannot be used to predict the long-term effects of different fire regimes, such as annual or biennial burning, but the changes observed were measurable for less than 1 yr. If the burning of the alfalfa stubble were done every 3rd yr, it seems unlikely that this practice would be detrimental to the soil characteristics examined.

Agrispon—friend or foe? The "soil conditioner" Agrispon has been sold privately to Canadian farmers but is not licensed for sale. The manufacturers claim that Agrispon will promote crop yields by hastening germination, increasing drought resistance, fixing atmospheric N_2, and generally stimulating plant growth, but our research did not substantiate these claims. Agrispon contained insufficient N and P and other micronutrients to stimulate plant growth in western Canadian soils. Agrispon contained only 10 times more bacteria than Lethbridge tapwater and none of the bacteria isolated were capable of fixing atmospheric N_2, either in symbiosis with legumes or in asymbiotic association with non-legumes, nor were any of the bacterial isolates plant or human pathogens. Agrispon also had low numbers of fungi (*Penicillum* spp., *Fusarium* spp., Mycelia Sterilia), approximately 10/mL, and no algae were isolated. The addition of Agrispon as seed-applied, pre-plant-incorporated, a combination of these two, or postemergence product had no consistent effect on germination and no effect on any parameter of plant yield of wheat, barley, field beans, or corn relative to the unfertilized control. Agrispon cannot be recommended for licensing in Canada or for private import by producers.

Water and climate

Irrigation systems scheduling. A hydrologic approach to assessing water losses during the peak season from an irrigation canal system, in lined and unlined canals of two reaches of the Lethbridge Northern Irrigation District, has been developed. The study was conducted during normal operation of the irrigation district. Continuous inflow and outflow hydrographs were computed at selected sites for the 1983 irrigation season to determine water used and lost in each of the canal reaches. Numerous field tests were conducted to assess the irrigation applications and to determine water losses in the distribution system during a given period of time that included peak water demand. The average water losses from the distribution system were 37.3% and 43.7% for lined and unlined canals, respectively. Much of the water loss from the partially reinforced concrete canal system appears to be attributable to a 3-km earthen ditch that receives water from a grouped turnout of the lined canal. Computed

water losses would be less if applications were in accordance with optimum sprinkler design.

LANDSAT data for mapping soil salinity. Methodology was developed for using satellite (LANDSAT) data from all four spectral bands to delineate and map soil salinity in 90 000 km^2 of land in southern Alberta. Areas of high salinity were delineated on selected scenes from LANDSAT tapes and extrapolated to other scenes. Manual interpretation of contrast-stretched photographs was transferred to 1:50 000-scale maps and summary maps at 1:250 000-scale were prepared. Ground data from 24 selected sites and other resource material were used to assist the interpretation. Accuracy of the maps was verified in the field by district agriculturists and salinity specialists. The results indicate that the probable accuracy of mapping was within 75%. Based on these maps, 10.7% of the land was salinized (3.6% natural, 7.1% secondary). Although the method was not fully automated, it was faster, less costly, and apparently as accurate as current ground methods of visually identifying and mapping salinity. It is now possible to prepare other salinity maps from historic and future data for comparison with the 1981 base map in order to determine changes in area affected by salinity.

Solonetzic soil management. A Solonetzic soil near Vauxhall, Alta., under a semiarid climate was highly variable in both physical and chemical properties. Amelioration by irrigation and subsoiling improved the productivity of the soil. Irrigation improved its salinity and sodium adsorption ratio (SAR) and the yield of wheat and subsoiling enhanced the irrigation effects. However, subsoiling had no significant effects on the soil salinity and SAR of this soil under nonirrigated conditions.

Assessment of drought effects. Many of the seemingly unrelated events of irrigation water-supply problems, grasshopper infestations, and dryland crop failures that occurred during the summer of 1984 can be related to a sequence of climatic events that began during the previous year. Even before the 1984 growing season began, analysis of precipitation data, overwinter soil moisture measurements, snowpack surveys, river-flow data, and grasshopper survey information indicated that the potential existed for serious agricultural problems in southern Alberta. Examination of historical data indicated that the drought of 1984 was as severe as those encountered during the 1930s. The effects on agriculture, however, were less severe.

Biotechnology

Estimation of N_2 fixation in field-grown legumes. Two techniques are commonly used to estimate N_2 fixation in field-grown legumes: total nitrogen balance and methods based on the principle of ^{15}N isotope dilution. A comparison of these two techniques of estimating N_2 fixation in several experiments over 3 yr showed that nitrogen balance generally resulted in a low estimate of N_2 fixation and was consistently less precise (higher experimental error). Even when high correlation coefficients were found between the two methods, the unacceptable characteristics of the regression equations (i.e., deviation from a slope of unity and a y-intercept of zero) made predictions difficult. Nitrogen balance was most reliable in experiments when soil N was low so that the non-fixing plants showed signs of N deficiency by anthesis. Only in one circumstance will nitrogen balance accurately quantify N_2 fixation: i.e., when efficiency of fertilizer N utilization (or in unfertilized situations, soil N uptake) of the fixing plant is identical to that of the non-fixing plant. Since this occurs sporadically, nitrogen balance cannot be used with confidence to estimate N_2 fixation in field-grown legumes. This means that researchers must have access to ^{15}N analytical facilities and establish experiments to produce reliable conversion factors between ^{15}N isotope dilution and the more traditional methods of estimating N_2 fixation.

Proper inoculation of legumes. Inoculation of legumes is essential to the establishment of a successful N_2-fixing symbiosis in western Canadian soils that lack indigenous soil rhizobia. A comparison was made between commercial and non-commercial adhesive agents for optimizing inoculation of King Grain line X005 soybeans with seed-applied, powdered, peat-based inoculant. Gum arabic (40%, wt/vol) and carboxymethyl cellulose (4%, wt/vol), available only from chemical supply houses, were excellent adhesive agents, binding over 800 mg of the inoculant per seed and protecting the rhizobia from desiccation. Wallpaper glue (10%, wt/vol), readily available in the market place and in common use by some farmers, bound 894 mg of inoculant per seed. The two most readily available commercial adhesive agents, Nutrigum and Nitracoat, bound similar amounts of inoculant. The use of water as an adhesive agent did not nourish the rhizobia or protect them from desiccation and cannot be recommended. Application of the peat inoculant as a dry powder was also unsatisfactory. The other 12 adhesive agents

tested were intermediate in their performance. The three best adhesive agents (gum arabic, carboxymethyl cellulose, and wallpaper glue) bound over 800 mg of inoculant to the seed, resulting in over 10^6 viable rhizobia per seed and more than 100 nodules per plant.

Mycorrhizal fungi activity in soils of different pH. Vesicular-arbuscular mycorrhizal (VAM) fungi are indigenous to almost all soils and have been shown to aid the growth and nutrition of most crop species. They are, however, affected by soil conditions such as pH. Lime was added at four levels to pots containing an acid black Chernozemic soil. VAM adapted to neutral pH were added to half the pots and alfalfa was planted. Indigenous VAM, adapted to acidic conditions, became less beneficial as the pH rose. Increased growth due to VAM addition was reflected in increased plant phosphorus uptake. Added VAM root colonization increased as the pH rose, whereas indigenous VAM colonization levels decreased. These results show that in cases of reclamation, a selected VAM could be more beneficial to crop growth than the indigenous VAM.

Solubilization of rock phosphate with soil fungi. Eighteen rock phosphates (RP) from 11 countries were used to test the ability of five fungal isolates to solubilize P. These cultures were previously determined to be superior to 124 other isolates in phosphate-solubilizing (PS) ability. PS of the different RP ranged from an average of 1.7% to 34% of the P content being released in 14 days in liquid media. The best isolate released an average of 40% of the P, which included several samples releasing above 85% of the P in the sample. P solubilized by one of the isolates was highly correlated with the growth responses of wheat following the addition of RP. These results indicate the possibility that the fungus could be used as a rapid bioassay for RP availability.

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Pacific Region
Région du Pacifique

S.C. Thompson

H.A. Reid

Director General	*Directeur général*	S.C. Thompson, BSc, MA, PhD, ndc
Program Specialist	*Spécialiste en programmes*	Vacant
Chief, Administration	*Chef de l'administration*	H.A. Reid

PREFACE

The Pacific Region of the Research Branch, with responsibility for five research stations and four experimental farms and substations, is now over a year old. The acting director general, Dr. W. Baier, returned to Ottawa, and the incumbent director general reported for duty on 20 August 1984. At the same time, the program specialist, Dr. H. R. Davidson, accepted a position as Director of the St. John's West Research Station in Newfoundland, where he moved on 6 August 1984. Dr. A.R. Forbes, Head of the Entomology Section and now Assistant Director at the Vancouver Research Station, served as acting program specialist during the preparation of the operational plans for 1985–1986. Pacific Region Headquarters in Vancouver has a staff allocation of eight person-years but both the program specialist and the economist positions are vacant. Each of the stations is contributing to the productivity and efficiency of the agriculture and food sector in British Columbia, as well as fulfilling its specialized mandate for research that is of national and international application. The results of research were conveyed to various clients in 88 research publications placed in national and international journals and 52 miscellaneous publications.

The Agassiz Research Station, in its animal program, concluded a long-term study of Holsteins and Holstein crosses for beef production; found a dried bacterial culture to be an effective additive in preserving forage nutrients for lactating cows; and discovered a stable-isotope method for determining absorption of dietary copper in livestock. In its crops research program, the station found that zucchini production was accelerated by use of mini-tunnels. Research continued into soil fertility evaluation, as well as into studies designed to minimize land degradation.

The Kamloops Research Station showed that the dates of grazing bluebunch wheatgrass and rough fescue profoundly affected subsequent productivity and vigor. Recovery of grasslands was monitored after various degrees of use and misuse. Fertilization recommendations for reed canarygrass on organic soils were formulated and turned over to the Provincial Soil Test Lab. Timothy was shown to be preferrable to meadow foxtail as pasture species for beef production in British Columbia. In Alberta, meadow foxtail is the recommended species.

The Saanichton Research Station emphasizes biological control of insect pests and diseases in vegetable crops. Among the positive results were yellow sticky traps for monitoring and reducing whitefly populations in greenhouses and identification of a potential biocontrol agent for powdery mildew in cucumbers. Nutrient film technology for hydroponic production of tomato and lettuce was successfully transferred from Europe. Production of kiwi fruit in coastal British Columbia was also introduced. Research on woody ornamentals yielded promising results with rooting of cuttings of rhododendron and camellia. The solar energy program demonstrated that thermal curtains are economically feasible in Canada, if light levels are not reduced.

The Summerland Research Station reported the effects of sewage lagoon effluent on fruit-tree and vegetable crops in Osoyoos. A cherry cultivar that is a superior indicator of little cherry disease has been selected and made available. Optimal dosages and storage conditions for methyl bromide were established for control of codling moth in apple. In processing, a new enzyme method to increase juice yield has elicited industry interest, and a patent is pending on a method to prevent pear juice from browning.

The Vancouver Research Station, through its biotechnology program, is about to grant a licence to Institut Armand Frappier for marketing monoclonal antibodies as diagnostic kits for plant viruses and potato bacterial ring rot. A method for storing labile plant viruses as powdered inocula has permitted retention of virulence for up to 10 yr. The virus eradication program for seed potatoes has resulted in total freedom from potato viruses X and S in the entire Pemberton Valley and in 75% of the Cariboo. In the integrated pest management program, a pheromone for use against the black-headed fireworm, a serious pest of cranberry, proved successful. A 3-yr program to devise a method for predicting late blight of potato has been successfully completed and is ready for commercial application.

Further information can be obtained directly from the relevant research station or from Pacific Region Headquarters, 750 Cambie Street, Vancouver, B.C. V6B 4V5.

S.C. Thompson
Director General

PRÉFACE

La région du Pacifique de la Direction générale de la recherche, dont relèvent cinq stations de recherches ainsi que quatre fermes expérimentales et stations satellites, existe maintenant depuis plus d'un an. Le directeur général par intérim, W. Baier, est retourné à Ottawa et le directeur général titulaire est entré en fonction le 20 août 1984. À la même date, le spécialiste de programmes, H.R. Davidson, a accepté le poste de directeur de la station de recherches de St-John's West, à Terre-Neuve, où il a déménagé le 6 août 1984. A.R. Forbes, chef de la Section d'entomologie et, depuis peu, directeur adjoint de la station de recherches de Vancouver, a occupé le poste de spécialiste de programmes par intérim au cours de l'élaboration des plans opérationnels de 1985-1986. À l'administration centrale de la région du Pacifique, à Vancouver, l'effectif de huit années-personnes est incomplet, puisque les postes de spécialiste de programmes et d'économiste sont vacants. Chacune des stations contribue à accroître la productivité et l'efficacité du secteur agro-alimentaire en Colombie-Britannique et chacune remplit son mandat spécialisé de recherches ayant des incidences sur le plan national et international. Les résultats des recherches ont été communiqués aux divers clients dans 88 articles scientifiques publiés dans des périodiques nationaux et internationaux et dans 52 publications diverses.

Dans le cadre du programme de zootechnie, les chercheurs de la station d'Agassiz ont terminé une étude à long terme portant sur l'utilisation des Holstein purs ou croisés pour la production de boeuf; ils ont découvert une culture bactérienne séchée qui est efficace comme agent de conservation des éléments nutritifs dans les fourrages destinés aux vaches allaitantes; et ils ont mis au point une méthode utilisant les isotopes stables pour mesurer l'absorption du cuivre présent dans les aliments chez le bétail. Quant aux recherches sur les cultures, elles ont révélé que l'utilisation d'un mini-tunnel permet d'accélérer la production des courgettes. La station a continué à mener des recherches sur l'évaluation de la fertilité des sols de même que des études visant à limiter la dégradation des sols.

À la station de recherches de Kamloops, on a démontré que les dates où l'on fait paître le bétail dans les champs d'agropyre à épi et de fétuque scabre ont une incidence importante sur la productivité et la vigueur subséquentes de ces plantes. On a étudié la reprise des pâturages après divers degrés d'emploi normal et abusif. On a transmis au laboratoire provincial d'analyse des sols des recommandations concernant la fertilisation de l'alpiste roseau sur des sols organiques. Il a été établi que, en Colombie-Britannique, le fléole des champs est une meilleure espèce de pâturage que le vulpin des prés pour la production de bovins de boucherie. En revanche, cette dernière espèce est celle recommandée en Alberta.

La station de recherches de Saanichton met l'accent sur la lutte biologique contre les insectes ravageurs et les maladies des cultures légumières. Parmi ces réalisations, mentionnons les pièges collants jaunes servant à contrôler et à diminuer les populations d'aleurode dans les serres ainsi que l'identification d'un agent potentiel de lutte biologique contre le blanc chez le concombre. La station a appliqué avec succès la technique européenne de culture sur film nutritif courant pour la production hydroponique des tomates et de la laitue. Elle a introduit la culture du kiwi sur la côte de la Colombie-Britannique. Les expériences sur le bouturage du rhododendron et du camélia, menées dans le cadre des recherches sur les plantes ornementales ligneuses, ont donné des résultats prometteurs. Quant au programme relatif à l'énergie solaire, il a permis de démontrer que l'utilisation d'écrans thermiques dans les serres constitue une solution rentable au Canada, si l'intensité de l'éclairage n'est pas réduit.

La station de recherches de Summerland a signalé les effets des effluents d'étang de sédimentation sur les cultures fruitières et légumières d'Osoyoos. Les obtenteurs ont sélectionné et mis au marché un cultivar de cerisier qui constitue une plante indicateur supérieure de la maladie de la petite cerise. On a établi les doses d'application optimales et les conditions d'entreposage du bromure de méthyle utilisé pour détruire le carpocapse de la pomme. Dans le domaine de la transformation, une nouvelle méthode enzymatique élaborée dans le but d'accroître le rendement en jus a suscité l'intérêt de la profession, et un brevet sera accordé sous peu pour un procédé qui empêche le brunissement du jus de poire.

La station de recherches de Vancouver, dans le cadre de son programme sur la biotechnologie, accordera sous peu à l'Institut Armand Frappier un permis pour la commercialisation des anticorps monoclonaux comme trousse de diagnostic des virus des plantes et de la flétrissure bactérienne de la pomme de terre. Une méthode d'entreposage de phytovirus labiles sous forme d'inoculum en poudre a permis la conservation de la virulence pendant des périodes allant jusqu'à 10 ans. Le programme d'éradication des virus des pommes de terre de semence a permis d'éliminer entièrement les virus X et S de la pomme de terre dans toute la vallée Pemberton et dans 75 % de la région Cariboo. Dans le cadre du programme sur

la lutte dirigée, l'utilisation d'une phéromone s'est avérée efficace pour lutter contre la tordeuse des canneberges, un ravageur important de cette culture. Au cours d'un programme d'une durée de 3 ans, on a établi une méthode de prévision du mildiou de la pomme de terre, qui pourra bientôt être appliquée à l'échelle commerciale.

Pour de plus amples renseignements, veuillez communiquer directement avec la station de recherches concernée ou vous adresser à l'administration centrale de la région du Pacifique, 750, rue Cambie, Vancouver (C.-B.), V6B 4V5.

S.C. Thompson
Directeur général

Research Station, Agassiz, British Columbia

PROFESSIONAL STAFF

J.E. Miltimore, BSA, MSc, PhD	Director
D. Neve,[1] BA	Administrative Officer
D.H. Frey, BSc	Analyst Programmer
M.C. Vidal,[2] BA, MLS	Librarian

Animal Science

L.J. Fisher, BSA, MSc, PhD	Head of Section; Dairy cattle nutrition
W.T. Buckley, BS, PhD	Ruminant mineral biochemistry
R.J. Forrest, BSA, MSA, PhD	Animal physiology, meat studies
E.E. Gardiner, BS, MS, PhD	Poultry nutrition
J.R. Hunt, BSA, PhD	Poultry physiology
Vacant	Poultry behavior

Crop Science

J.A. Freeman, BSA, MSA, PhD	Head of Section; Physiology of small fruits, herbicides
N.P. Ames-Gottfred,[3] BSA, MSA	Forage breeding and management
S.G. Fushtey, BSc, MSc, PhD	Turf management, cereals
J.C.W. Keng, BSc, MSc, PhD	Crop and soil management
C.G. Kowalenko, BSA, MSc, PhD	Soil biochemistry and fertility
A.R. Maurer, BSA, MSc	Physiology of vegetable crops
P.W. Perrin, BSc, PhD	Postharvest physiology

Departure

J. Repstock Retired 13 July 1984	Administrative Officer

VISITING SCIENTIST

R.C. Newberry, BSc, PhD National Research Council of Canada visiting fellow, 1983–1985	Poultry behavior

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[1]Appointed 16 July 1984.
[2]Seconded from Libraries Division, Finance and Administration Branch.
[3]On educational leave, University of Guelph, October 1984 to December 1986.

INTRODUCTION

Research at Agassiz is directed at solving problems for a wide variety of commodities. Dairy cattle research, with particular emphasis on mineral nutrition and utilization of hay and grain silages, applies beyond the immediate dairying region in south coastal British Columbia. Results of studies on laying hens and broilers as well as on behavior are used internationally.

Crops research tends to be more applicable to British Columbia. Corn silage, forage, berries, vegetables, filberts, and turf are the most important commodities served. Herbicides, soil fertility, soil and water management, forage crops management, and vegetable storage management–physiology are the principal disciplines.

Some highlights of 1984 research include the discovery that rapid cooling of carrots reduced black root rot; use of plastic mulch and mini tunnels hastened the zucchini harvest by up to 40 days; a dried culture of two bacteria when mixed with silage preserved a greater proportion of corn silage nutrients for the lactating cow; a method for using stable isotopes of copper in nutrition studies was verified as reliable and satisfactory for evaluating copper storage and utilization.

Additional details concerning the research program and results achieved may be obtained by requesting copies of the listed publications and other informal reports. Requests should be directed to the Research Station, Agriculture Canada, P.O. Box 1000, Agassiz, B.C. V0M 1A0.

J.E. Miltimore
Director

ANIMAL SCIENCE

Testing of an additive for grass silage. A silage additive, Silogen, consisting of a dried culture of *Lactobacillus acidophilus* and *Aspergillus oryzae* was tested in a feeding trial with lactating cows and a digestibility trial with sheep. The silage treated with the additive had a higher digestibility of organic matter, acid detergent fiber, and nitrogen compared to the untreated silage. It was concluded that this additive was effective in preserving a greater proportion of the forage nutrients for utilization by the lactating cow.

A comparison of two housing systems for calves. Thirty-six male Holstein calves were used to compare two types of pens. One type of pen was 0.66 m wide with a grated floor, whereas the other type was 1.36 m wide, equipped with solid floors and bedded with straw. Calves housed in the larger pens bedded with straw had faster rates of gain and more efficient feed conversion than those housed in the smaller pens. There were differences between the two groups of calves in differential white cell count, which may have reflected an increased amount of stress for calves housed in the smaller pens.

Stable isotope tracer methods for determining absorption of dietary copper in dairy cattle. New methods, utilizing the stable isotope copper-65, have been developed for determining the rate of absorption of dietary copper in dairy cows. Three methods were tested in order to verify results by comparisons of different procedures for determining dietary absorption. In a trial with six dairy cows the samples required for all three methods were taken simultaneously from the animals. Measured rates of copper absorption showed good agreement between two of the methods with means (±SE) of 11.0 ± 1.1 and 11.6 ± 2.0 mg/day being estimated. Agreement between the two procedures confirmed the reliability of determining the absorption of dietary copper, utilizing techniques based on the stable isotope copper-65.

Calculation of stable isotope enrichment for tracer kinetic procedures. The most commonly used method, atom percent excess, of expressing stable isotope enrichment was found to produce a significant error in some tracer kinetic procedures. Preliminary testing of the manipulation data from isotope enrichment techniques identified two procedures that might be suitable for stable isotope tracer investigations.

Effect of dietary reserpine on the incidence of sudden death syndrome (SDS) in chickens. The use of the tranquilizer reserpine in the diet of chickens to reduce the incidence of SDS was investigated. Reserpine in the diet at levels of 0.0, 0.5, 1.0, and 1.5 mg/kg had no significant effect on body weight but reduced feed-to-gain ratios. In a second experiment with reserpine in the diet at levels of 1.5 and 3.0 mg/kg resulted in lower body weights at 3, 7, and 10 wk of age. Feed-to-gain ratios were not influenced by reserpine. It was concluded that neither total mortality nor mortality due to SDS was influenced by dietary reserpine.

Conifer foliage as a pigmentation source for laying hens. Muka (dried ground needles and small twigs) could be used as a source of yolk pigmentation without adverse effect on other production and quality parameters. However, compared to the control alfalfa meal, muka was more variable in its pigmentation properties, which indicated the importance of standardized procedures for handling muka.

CROP SCIENCE

Chemical control of snow mold in turf. Fifteen different chemicals were tested during two seasons for control of snow mold on bent grass greens at three sites in south central British Columbia where *Fusarium nivale* was the predominant causal fungus. The most effective among registered fungicides were those containing quintozene as the active ingredient (Quintozene 75W and Proturf FFII) and those containing benzimidazoles (Tersan 1991 and Easout). Dithane M45 applied at 240 g/100 m^2 also gave good control at all sites. Daconil 2787 and Rovral gave satisfactory control at two sites where disease incidence was low (9%), but they were not effective at the third site where disease was exceptionally high (80%). The four experimental fungicides in the trials, Bayleton, BCI-100, Banner, and Bloc all yielded promising results.

Study of experimental design of hybrid corn trial plots. A 2-yr field experiment to compare the testing results of single row, double row, and triple row hybrid corn trial plots was conducted at two locations in British Columbia. At the early variety location, seven corn hybrids were used and at the late variety location, eight varieties were used. A specially designed statistical analysis procedure was employed to analyze the data. In the first analysis of variance, row types were analyzed separately. The residual variances were then compared to test the precision of the results coming from the different row types. In the second analysis of variance the interaction of hybrid × plot type and the interaction of hybrid × plot type × year were analyzed.

Statistical analysis suggested that the results of this 2-yr experiment did not indicate that the shading effect is of much concern in terms of percent whole crop dry matter, dry matter yield, and grain content. Therefore, a single row hybrid trial remains the most economical testing design.

Controlling black root rot of carrots. The causal agent of black root rot, *Chalara elegans* (Nag Raj & Kendrick), has caused serious storage losses of commercial carrots in British Columbia. Studies were undertaken in cooperation with the B.C. Ministry of Agriculture and Food and a commercial grower to determine appropriate post-harvest handling techniques that would mitigate against future losses caused by this fungus.

To insure infection potential, carrots were inoculated with *Chalara* by spraying with a suspension of endoconidia immediately after harvest. Treatments included no cooling, delayed cooling, hydrocooling with and without chlorinated water, and storage at either 1°C or 5°C.

The results showed that overnight holding at ambient temperatures prior to cooling and storage was the most important factor contributing to the establishment of infection. There were also significantly more severely infected carrots from the 5°C storage room when the carrots were evaluated after three subsequent days at room temperature. It is expected that under commercial conditions, where the cooling capacity of storage rooms is limited, the benefit of hydrocooling would also be significant.

Sulfur deficiency in soils in the Fraser valley of British Columbia. Until 1979 it was assumed that sulfur in soil and precipitation in the Fraser valley of British Columbia was adequate for crop production. However, research at Agassiz has shown that field applications of sulfur can result in substantial (up to 80%) increases in forage grass production. Studies have indicated that responses to sulfur application are complex. Responses by grass to sulfur applications have been very seasonal and site specific. Yield reductions due to sulfur have also been recorded. The form and time of application influence the efficiency of supplying required sulfur. The complexity of the response and of sulfur chemistry in plant and soil samples is limiting the establishment of a deficiency prediction method.

Farmers are now commonly incorporating sulfur fertilizer applications. A deficiency prediction system is required to prevent costs of unnecessary sulfur applications, possibilities of yield reduction, and soil acidification from acid-forming sulfur fertilizer. Research work for a prediction system is continuing. The implications of sulfur applications on micronutrients, especially for forage quality, are also being examined.

Zucchini production accelerated. Zucchini production can be accelerated by up to 40 days, using polyethylene-covered mini tunnels and black plastic mulch on seedlings started in soil blocks in mid-March and transplanted to the field in early April. This accelerated rate of growth was accomplished by an improvement of the microclimate around the plant. Mini tunnels covered with polyethylene increased soil temperature at 4 P.M.

by an average of 3.3°C and air temperature by 5.3°C during May and June 1984.

Pre- and post-planting treatments for strawberries. Trifluralin 1.1 and ethalfluralin 1.1 kg/ha were tested as pre-planting, soil-incorporated treatments for strawberries, cultivar Totem. In addition, both herbicides were followed by terbacil at 0.3 and 0.5 kg/ha when strawberry plants were established. Ethalfluralin gave better control of broad-leaved weeds than trifluralin, but shepherd's-purse and pineappleweed escaped in all plots.

Ethalfluralin tended to give better annual blue grass control than trifluralin but some blue grass escaped in all plots. Both herbicides gave complete control of barnyard grass. Terbacil applied postemergence to the plots previously treated with either trifluralin or ethalfluralin gave good residual control. Neither trifluralin nor ethalfluralin affected the crop detrimentally. Terbacil, however, did cause some initial leaf chlorosis and necrosis. But, by midsummer, the strawberry plants in all plots had recovered. No treatments affected total number of runner plants/mother plant or the number of rooted runners. Marketable yields for all treatments were equal to or better than those of the check plots.

Control of fruit rot in strawberries. The fungicides captan and UBI-A815 were evaluated for control of preharvest and post-harvest fruit rot in Totem strawberries. The incidence of fruit rot in the field for the unsprayed plots was 8.5%. All treatments significantly reduced preharvest fruit rot. There was no effect of treatment on berry size. The yield of sound berries was increased by all treatments. *Botrytis* and *Penicillium* were the main contributors to post-harvest rots. Both fungicides significantly reduced post-harvest rots. Captan having an active ingredient (a.i.) of 1.7 kg/ha proved significantly better than UBI-A815 having an a.i. of 0.5, 1.0, or 1.5 kg/ha. Since rot control increased with rate, it is suggested that perhaps UBI-A815 should be applied at higher rates than those tested.

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Research Station, Kamloops, British Columbia

PROFESSIONAL STAFF

J.D. McElgunn, BSc, MSc, PhD	Director
P.A. Dickson,[1] BSA	Administrative Officer
W. Majak, BSc, MSc, PhD	Biochemistry
A. McLean, BSA, MSc, PhD, FAIC, FSRM	Range ecology
D.A. Quinton, BS, PhD	Range management
D.G. Stout, BSA, MSc, PhD	Plant physiology
A.L. van Ryswyk, BSA, MSA, PhD	Soil science

Prince George Experimental Farm

W.L. Pringle, BSA, MSF	Superintendent; Forage
K. Broersma,[2] BSA, MSc	Forage agronomy, soils
L. Rode, BSc, MS, PhD	Animal nutrition

VISITING SCIENTIST

A. Muir,[3] BSc, PhD	Plant biochemistry

[1]Transferred 1 January 1985.
[2]On educational leave to 1 August 1984.
[3]Resigned 1 October 1984.

INTRODUCTION

The Kamloops Range Research Station and the Prince George Experimental Farm develop new scientific and technological information from two research programs, namely beef and forage crops. Our research is conducted on land in the dry-belt interior of British Columbia, which varies from highly productive irrigated land growing alfalfa, corn, and other forages, to true treeless grasslands, to forested ranges and subalpine and wetland meadows. The major agricultural users of these lands are cow–calf ranchers, who must manage in a political climate involving agriculture, forestry, and wildlife for integrated use of the natural resources.

Our staff situation has remained somewhat static in 1984: we welcome the return of Klaas Broersma from educational leave (University of Alberta), and we will miss the association with Dr. Alister Muir, a postdoctorate fellow who worked on knapweed allelopathy and assisted us with many aspects of chemical analysis, especially on the high-pressure liquid gas chromatograph.

Only a portion of the current research is presented in this brief report that indicates the diversity of the over all research productivity.

Those wishing further information on our research activities are encouraged to contact the director or the scientists at the Agriculture Canada Research Station, 3015 Ord Road, Kamloops, B.C. V2B 8A9, or the Experimental Farm, R.R. No. 8, RMD No. 6, Prince George, B.C. V2N 4M6.

J.D. McElgunn
Director

RANGELAND STUDIES

Diets of cattle grazing high altitude ranges

Diets of cattle grazing clearcut sites at elevations above 1000 m that were seeded to timothy (*Phleum pratense*), orchard grass (*Dactylis glomerata*), intermediate wheat grass (*Agropyron intermedium*), smooth brome grass (*Bromus inermis*), and alsike clover (*Trifolium hybridium*) in central interior British Columbia, consisted of about 59% grass, 33% forbs, and 9% browse. Over all mean diets of cattle grazing an area continuously over the summer were about 73% similar to diets of cattle grazing the same area on a deferred rotation basis. Orchard grass and timothy were the most important grasses consumed by cattle. Lupine (*Lupinus articus*), horsetail (*Equisetum pratense*), and aster (*Aster* spp.) were the most important forbs, and willow (*Salix* spp.) was the most important shrub. Management of clearcuts at this altitude should be based on these species. Season of use and productivity of these plant species should be accounted for when forage allocations are made for cattle, deer, and moose on these sites.

Cattle diets from these areas changed gradually from July through September and from site to site. The most pronounced change was in September when cattle were introduced onto a previously ungrazed site. Cattle grazing clearcuts were somewhat selective, seeking the more palatable forage and departing from a predominantly grass diet.

A knowledge of the conditions that produce an abundance of forbs and the time of the curing of grasses would help managers optimize use of these ranges.

Grazing studies on timothy and meadow foxtail

A grazing experiment was conducted to compare timothy and meadow foxtail as pasture forage species. Twenty-four yearling steers grazed on either timothy or meadow foxtail. Average daily gain (ADG) during the 103-day grazing period was 1.15 kg/day for animals grazing timothy but only 0.95 kg/day for those grazing meadow foxtail. These results are similar to previous results obtained at the Experimental Farm.

Following the grazing period, steers were fed grass hay for a further 50 days. During this period, animals that had previously grazed on meadow foxtail gained 0.54 kg/day compared to 0.64 kg/day for steers that had previously grazed on timothy. It is expected that steers performing poorly during one period of the growth cycle will outperform their faster growing counterparts once nutrition is improved. This compensatory growth phenomenon was not observed and there was actually a negative carryover effect with meadow foxtail, indicating that some factor within meadow foxtail inhibits animal performance even after cattle are no longer consuming the forage.

Response of steers to implants and additives

The effects of anabolic implants and feed additives were compared under pasture condi-

tions. Seventy-five yearling steers were given implants containing either zearanol (Ralgro) or 17B-estradiol (Compudose), or were given no implants (control). Over the 110-day grazing season, ADG was similar for all implant types at 0.95 kg/day. Unimplanted cattle gained only 0.80 kg/day. There was no advantage seen when zearanol was re-implanted at the beginning of the experiment (two doses) or after 90 days. Gain obtained from a single growth implant resulted in an extra 13 kg of saleable beef over the pasture season. In addition to implant treatments, steers were provided with barley (0.5 kg/day per head), barley plus lasalocid (Bovatec; ionophore antibiotic), or no supplemental feed. Extra barley had no effect on animal performance (0.87 versus 0.84 kg/day) but performance of animals receiving lasalocid was improved 21.6% (1.02 kg/day). Combination of a growth implant and lasalocid increased ADG by 51% over animals receiving neither.

Timber milkvetch (*Astragalus miser* var. *serotinus*) poisoning

When 3-nitropropanol (NPOH) was injected into the rumen (30 mg/kg), abomasum (10 mg/kg), or small intestine (10 mg/kg) of sheep, it was rapidly absorbed and converted to 3-nitropropionic acid (NPA). The reticulo-rumen was the major site of absorption for the miserotoxin aglycone, but the abomasum and the small intestine also had the capacity to absorb NPOH. When NPA was injected into different regions of the alimentary tract, the reticulo-rumen was also the major site of absorption. Absorption of NPA or NPOH from the small intestine was much more rapid than from the abomasum. Plasma levels of NPA and inorganic nitrite were higher after dosing with NPOH than with NPA, indicating a more rapid rate of uptake of the aglycone.

Miserotoxin, the toxic component of certain *Astragalus* spp. (Leguminosae), was rapidly hydrolyzed to 3-nitropropanol (NPOH) in the rumen of cattle dosed with timber milkvetch. The NPOH showed a rapid rate of disappearance from the rumen with an average half-life of 1.24 h. In contrast to the passage of Co-EDTA, which showed an exponential rate of increase in the abomasum, NPOH was not detected in abomasal fluid collected from dosed cattle. Rapid absorption of NPOH from the rumen was shown by plasma levels of NPA and inorganic nitrite, but conversion of NPOH to NPA was not observed to any significant extent in the rumen.

Cyanide potential of Saskatoon (*Amelanchier alnifolia*)

Saskatoon browse (containing prunasin) was administered intra-ruminally to examine cyanogenesis in the bovine rumen. Maximum levels of hydrogen cyanide (HCN) in rumen fluid were observed 0.5 h after dosing, after which HCN showed rates of disappearance ranging from -0.99 to -8.48 μg HCN $mL^{-1} h^{-1}$. Thiocyanate formation was detected in vivo and the degree of HCN detoxification was significant where it disappeared at slower rates. In vitro trials were also conducted to determine the effect of cattle diet on microbial degradation of amygdalin. Rates of HCN production from amygdalin ranged from threefold to 11-fold with rumen inocula from the same diet. Rate magnitudes in vitro were not closely related to cattle diets. Cyanogenic activity was found widely but unevenly distributed among pure cultures of rumen bacteria. Production of HCN from amygdalin occurred in 30 out of 68 strains of rumen bacteria tested. Thiocynate formation was also detected in vitro when mixed rumen cultures were incubated with amygdalin or sodium cyanide.

Pasture bloat in cattle

Daily weather records from seven consecutive growing seasons and daily nitrogen levels in alfalfa herbage from the past four seasons were studied in order to identify relationships with bloat in cattle. The cattle tended to bloat as a group rather than independently. Bloat occurred on at least 30% of the days observed in each season, but in the two driest, warmest years bloat occurred on at least 46% and 63% of the days observed. Days on which bloat occurred were preceded by lower maximum and minimum temperatures on the average than days on which bloat did not occur but the difference in temperature was small. On a daily basis, no differences were observed between days of bloat and no bloat in hours of sunshine, temperature range, precipitation, solar radiation flux, or potential evapotranspiration. The concentration of total nitrogen, soluble nitrogen, and soluble protein nitrogen in the feed was higher on days when bloat occurred than when it did not occur.

Pinegrass growth and physiology

Rhizome translocation. The influence of connecting rhizomes on the percentage of total nonstructural carbohydrates (TNC) was evaluated by comparing results from sods with severed rhi-

zomes to results from sods with intact rhizome connections.

Severing rhizomes had no effect on the percentage of TNC of rhizome plus roots of nonclipped sods. However, for clipped sods, the percentage of TNC was lower if rhizomes had been severed. Presumably, when rhizome connections are left intact, surrounding nonclipped tillers translocate carbohydrates to rhizomes plus roots of clipped tillers within a sod. This result has important implications in the grazing resistance of pine grass. Since grazing typically involves an uneven utilization of a grass stand, the ungrazed or lightly grazed tillers should play an important role in maintaining the over all vigor of a pine grass stand.

Characterization of vegetative growth. Number of tillers m^{-2} and number of leaves per tiller were counted at intervals during the growing seasons of 1978 and 1979. Tiller height was recorded during 1978, 1979, and 1982, whereas shoot weight was recorded at intervals during 1982. Pine grass had up to four leaves per tiller, but on average only three leaves were present by the time growth ceased in July. Total leaf blade area was reached in July and was mainly comprised of two leaves. Total leaf blade area (y) was predicted from tiller height (x): $y = 0.39375 + 0.051604x + 0.00419223x^2$ ($R^2 = 0.97$). A large proportion of leaf blade area was dead by the end of July. Tiller weight reached a maximum in July; it increased during May to July owing to an increase in number of leaves, leaf area, and specific weight of leaves. Growth analysis indicated that net assimilation rate (NAR), and relative growth rate (RGR) were high in mid-May and then gradually decreased to zero in July. This basic information will contribute to a better understanding of the production and grazing resistance of this important grass.

Bluebunch wheat grass growth and physiology

Herbage removal and survival. In 1979 most plants, or bunches, that had been clipped during the spring of 1978 produced some tillers, but in 1980 most plants that had been clipped during the spring of 1979 were dead. Root water status during the summer of clipping was similar in 1978 and in 1979. Also, root TNC levels were similar in the fall following both the 1978 and 1979 clippings. Thus, plant survival following herbage removal is not simply related to a particular degree of herbage removal, tissue water status, or level of TNC. The abiotic conditions following herbage removal play a key role in determining plant survival.

Vigor following herbage removal. Following herbage removal by clipping, several plant characteristics were evaluated as measures of the effect of clipping. Sensitivity of a particular measure of vigor was evaluated by calculating the change in the measure relative to a control: the greater the clipping induced change from the control value relative to the control value the greater the sensitivity. The ranking of characteristics in terms of sensitivity to herbage removal is as follows, the most sensitive being listed first: (*1*) number of reproductive shoots; (*2*) number of vegetative shoots; (*3*) percentage of TNC; (*4*) vegetative shoot height; and (*5*) occurrence of fall regrowth. In British Columbia, measures of vigor involving reproductive structures or shoots are not recommended. This basic information will be useful when evaluating the effect of grazing on bluebunch wheat grass.

Nitrogen fertilization of crested wheat grass

Moisture implications. The non-fertilized crested wheat grass at the dry, intermediate, and moist sites yielded 409, 417, and 579 kg/ha averaged over 7 yr of harvesting. At the dry site, N at 100 kg/ha significantly increased yield in 1973 only; N at 50 kg/ha increased yield in 1973 and 1974; and N at 25 kg/ha did not increase yield significantly in any year. At the intermediate site, N at 100 kg/ha increased yield in 1973 to 1975; N at 50 kg/ha increased yield in 1973 and 1974; and N at 25 kg/ha increased yield in 1973 only. At the moist site, N at 100 kg/ha increased yield from 1973 to 1977; but neither the 50 kg/ha nor the 25 kg/ha application of N caused increased yield in any year. These data illustrate the increasing nitrogen assimilation power of soil with increasing organic matter, as organic matter in the top 0–15-cm layer increased from 1.4 to 1.9 to 2.9%, respectively, in response to the increasing moisture and decreasing temperature of each site. The high organic matter/high moisture site required in excess of N at 50 kg/ha before a significant yield response occurred. In the last 4 yr of the trial, certain treatments had yields that tended to be less than the non-fertilized checks, but not significantly so. However, the over all average yields of fertilized crested wheat grass plots in the last 4 yr of the trial were above those of the non-fertilized plots.

Establishment of diffuse and spotted knapweed

As seeding density of knapweed was increased, the percentage of germination decreased, seedling death rate increased, and rosette size decreased. Although rosette numbers in the 1 yr of growth increased up to an optimal

sowing rate, seed production in the 2 yr was constant over all the sowing rates and plant densities. Lower percentages of both knapweeds bolted in the 2nd yr of growth as compared to the 1st yr. As a result, biological control agents feeding on seeds or other parts of mature plants attack only some of the established plants, making weed control by the insects introduced to date difficult.

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Research

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Saanichton Research and Plant Quarantine Station, Sidney, British Columbia

PROFESSIONAL STAFF

Administration

J.M. Molnar, BSA, MSc, PhD	Director
E.M. Ritchey	Administrative Officer

Scientific Support

M.A. Watson,[1] BA, MLib	Librarian

Ornamentals

C.J. French, BSc, PhD	Section Head: Woody ornamentals
W.C. Lin, BSc, MSc, PhD	Floriculture
J.P.L. Monette, BSc, PhD	Tissue culture
A.W. Chiko, BSc, MS, PhD	Viruses

Vegetables

E.M. Van Zinderen Bakker, BSc, MSc, PhD	Section Head: Physiology
H. Hartmann, BSc(Agr), MSc, PhD	Plant pathology
D.R. Gillespie, BSc, MSc, PhD	Entomology
C. Kempler, BSc, MSc	Vegetable nutrition

Plant Quarantine

R.C. Johnson,[2] BSA	Section Head: Grape viruses
D. Thompson,[3] BSc	Tree fruit viruses

Departure

G. Blair	Administrative Officer

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[1]Seconded from Libraries Division, Finance and Administration Branch.
[2]On educational leave, University of British Columbia, from September 1984.
[3]Food Production and Inspection Branch.

INTRODUCTION

The Saanichton Research and Plant Quarantine Station is the ornamentals and greenhouse vegetable research center for British Columbia and is responsible for the national postentry quarantine program. Emphasis is given to research on nutritional and physiological problems in floriculture, plant propagation, post-rooting development of nursery plants, eradication of viruses, rapid multiplication of grapes and ornamentals by tissue culture, and control of pests and diseases in vegetables and ornamentals. The station also conducts research in energy conservation, utilizing solar energy, thermal blankets, and a computerized climate control system. Requests for information or publications should be addressed to the Saanichton Research and Plant Quarantine Station, 8801 East Saanich Road, Sidney, B.C. V8L 1H3.

J.M. Molnar
Director

ORNAMENTALS

Management

Effects of high-pressure sodium (HPS) lighting and low-intensity incandescent (INC) night lighting on rooting of Rhododendrons. Increasing natural irradiance with HPS inhibited initial rooting of *Rhododendron* 'Unique' in fall but stimulated subsequent root growth of both Unique and Anna Rose Whitney cultivars. In spring, HPS stimulated root growth in the cultivar Unique but had little effect on the cultivar Anna Rose Whitney. Night lighting from INC stimulated rooting in the Unique and Anna Rose Whitney cultivars in both spring and fall. Natural irradiance appears adequate for greenhouse propagation of rhododendrons; low irradiance supplementary lighting is an inexpensive way to improve rooting.

Effects of supplementary HPS lighting applied at different times during spring propagation of woody ornamentals. Effects of irradiance on rooting woody ornamentals were studied by applying supplementary HPS at 0–8 wk, 8–16 wk, and 0–16 wk and compared with effects of propagation under natural irradiance. No effect of HPS was found in *Rhododendron* 'Pink Bountiful' and *Camellia japonica* 'Blood of China'. In *Rhododendron* 'Sonata', HPS stimulated only during the root growth period (8–16 wk). In *Picea pungens* 'Globosa', application of HPS during 0–8 wk inhibited rooting. In *Camellia japonica* 'Lady Clare', application of HPS during the root growth phase (8–16 wk) stimulated rooting. There was an interaction with the irradiance during the 0–8-wk period. The effects of supplementary irradiance were variable according to species, cultivar, and time of application.

Winter flowering of Alstroemeria. Winter flowering of *Alstroemeria* under a growing medium temperature of 10°C given at three different times, i.e., 22 August–21 November, 5 September–5 December, and 19 September–19 December, was compared with winter flowering under a control temperature of 16°C. Under 16 h of high irradiance lighting, these four treatments resulted in 83, 78, 71, and 70 flowering shoots per 0.45 m^2 during December 1983–April 1984. Under long days (low irradiance lighting), no differences in flower production were apparent. Results obtained during the first winter season indicated that soil cooling to 10°C for 13 wk overcame nonflowering of the cultivar Regina. The importance of irradiance was obvious; 75 flowering shoots per 0.45 m^2 under high irradiance and only 25 under low irradiance.

Propagation of Rieger begonia. Leaf-cuttings of the begonia *Rieger* 'Saanred' were taken from plants grown under (*1*) short days (SD, 8 h photoperiod), and (*2*) natural daylight (ND). Cuttings from each stock condition were further divided into the following propagation conditions: (*1*) night interruption with INC light, (*2*) night interruption with fluorescent (FL) light, (*3*) SD, and (*4*) ND. Cuttings from SD-treated stock plants produced more shoots per cutting and rooted better than those from ND-treated ones. Cuttings propagated under supplementary FL rooted better and had more shoots per cutting.

Propagation of Poinsettia. The number of cuttings produced by *Poinsettia* 'Annette Hegg Brilliant Diamond' was increased with high irradiance, HPS lamps compared with two levels of low irradiance HPS and ND. Stock plants grown under 16 h HPS lighting produced short, heavy cuttings. The number of cuttings per plant was unaffected by two levels of fertilization.

Diseases

Viruses infecting ornamentals. Tests revealed that some cultivars of *Alstroemeria* at this station were infected singly with alstroemeria mosaic

virus (AMV), doubly with AMV and an unidentified rod-shaped virus (AMV + R1), or doubly with an unidentified spherical and rod-shaped virus (S + R2). Virus infection was universal in the cultivars Beauty (AMV), Red Surprise (AMV), and Canaria (AMV + R1), sporadic in the cultivar Orange Beauty (S + R2), and absent in the cultivars Orchid and Regina. This is the first report of AMV in North America.

Green peach aphids (*Myzus persicae*), given short acquisition feeds (5–30 min) on detached leaves of variegated *Tolmiea menziesii* infected with cucumber mosaic virus, failed to transmit the virus to tomato or to cucumber. Similar results were obtained, using both short and long (each 4 h) acquisition feeds on intact plants.

SMALL FRUIT

Management

Kiwi fruit production on Vancouver Island. A late spring with cold temperatures caused flowering to be delayed by 3 wk. The possibility of frost increased with the approach of November, resulting in the crop being harvested only 1 wk later than last year. The reduced average fruit size of the best cultivar from 110 g in 1983 to 98 g in 1984 could be due to these factors.

Severe pruning of the vines after harvesting in 1983 reduced the number of fruit, the best cultivar yielding only 18 kg of fruit in 1984 compared with 25 kg in 1983.

Diseases

Detection of grapevine fanleaf virus (GFLV) by enzyme-linked immunosorbent assay (ELISA) of grapevine tissue cultures. Grapevine fanleaf virus was detected by ELISA of GFLV-infected grapevine tissue cultures. Cultures were tested at the stage of in vitro shoot proliferation and varied in age from 8 to 25 wk post-initiation. Twenty-seven of 29 cultures tested yielded positive results. The use of tissue culture with ELISA should facilitate year-round testing of new accessions by plant quarantine.

VEGETABLES

Management

Tomato cultivars in nutrient film technique (NFT). During the fall of 1983, six tomato cultivars (Fiesta, Dombo, Buffalo, Perfecto, Laura, and Abunda) were tested in NFT. Over the 10-wk harvest period, significant differences were found for all parameters investigated. Fiesta was considered the best cultivar producing the highest yield with the same percentage of extra large and large fruit as Dombo, which produced the highest average fruit weight.

In the spring of 1984, a second trial was conducted in NFT with three cultivars (Vedettos, Perfecto, and Fiesta). After 13 wk of harvesting, both Vedettos and Perfecto had significantly outproduced Fiesta. Fiesta, however, still had a significantly higher average fruit weight than the other two cultivars.

Cucumber cultivar trial. Five cucumber cultivars (Fidelio, Corona, Brustar, Brunex, and Brudania) were propagated with an 8 and 16 h light period, using HPS lamps. No significant differences were found. After planting in the greenhouse, no significant differences were found between the cultivars in either the number or weight of fruit produced by the plants raised under either photoperiod.

Overwintered cauliflower. Trials were conducted during the past few winters on the production of overwintered cauliflower. Suitable cultivars and planting dates for southern Vancouver Island were tested. Early August plantings resulted in higher total yield and larger head size than late-August plantings. The planting date had little effect on the date of harvest. It is possible to spread the harvest dates from February to June by selection of suitable cultivars.

Diseases

Biological control of powdery mildew. Powdery mildew is caused by the fungus *Sphaerotheca fuliginea* and is particularly troublesome because it quickly develops resistance to pesticides.

An extensive screening program has identified several potential biological control agents. One of these, a yeast (*Tilletiopsis* sp.), has been tested both in the laboratory and in the greenhouse on full-size cucumbers. Under greenhouse conditions, the yeast reduced powdery mildew five- to sixfold, achieving excellent control. The biological control agent for powdery mildew appeared quite tolerant to insecticides but showed some sensitivity to fungicides.

A range of ornamental and vegetable varieties, including gerbera, begonia, lettuce, pepper, and tomato were sprayed with the organism. No damage was observed, even after prolonged and repeated applications.

Yellow sticky traps for monitoring greenhouse whitefly. Early detection of greenhouse whitefly adults on greenhouse tomato and cucumber is critical to establishment of biological control using *Encarsia formosa*. Strips of bright yellow

plastic, coated on both sides with "Sticky Stuff" (Olson Products Ltd., Medina, Ohio) and hung vertically between plants in rows are effective traps for greenhouse whitefly.

In propagation houses, traps hung at a density of one, or more, per 100 plants catch whiteflies as soon as they invade the greenhouses. On tomato, after planting, five traps per 100 plants can predict populations of whitefly in greenhouses. On cucumber, traps at a density of one per plant indicate areas of high populations of whitefly. Traps also caught sufficient whitefly adults to favor the successful establishment of *E. formosa*.

GREENHOUSE ENERGY CONSERVATION STUDIES

Solar energy. The cotton solar collecting panels in the east–west-aligned solar shed were replaced with reinforced polyethylene coated with flat black latex. Capital costs were reduced by \$3.42 m^{-2} and collector efficiency was doubled to 59%. The solar shed has used 34% less energy annually. Structural modifications to triple the rock storages are under way. The air circulation system will be more aerodynamic and less expensive. Increased energy savings of 43% are forecast.

The earth thermal storage (ETS) system has realized annual energy savings of 23%. The air circulation system is being redesigned for application in gutter-connected houses. The capital cost will be reduced by approximately \$3.03 m^{-2} and performance should increase by a factor of 1.3.

Evaluation of woody-host indicators in the greenhouse or controlled environment conditions to decrease the time needed to detect non-sap-transmissible viruses is continuing. Several new indicators for grapevine leafroll are also being evaluated for use under local conditions.

PLANT QUARANTINE

Virus indexing of tree fruit and grape. In 1984, 53 tree fruit, 24 noncertified grape varieties, and a total of 31 audit samples from foreign certification schemes were received for virus indexing.

The heat therapy program now contains 118 grape varieties and 80 tree fruit varieties. Tissue culture has proved valuable for propagation of heat therapy shoot tips that would not survive conventional micrografting. This year 8 *Malus* clones, 10 *Prunus* clones, 1 *Pyrus* clone, and 2 *Vitis* clones were released from the heat therapy program in addition to 31 clones of tree fruit and grape released from the indexing program.

Evaluation of woody-host indicators in the greenhouse or controlled environment conditions to decrease the time needed to detect non-sap-transmissible viruses is continuing. Several new indicators for grapevine leafroll are also being evaluated for use under local conditions.

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Research

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Research Station, Summerland, British Columbia

PROFESSIONAL STAFF

G.C. Russell, BS, MS, PhD	Director
H.F. Madsen, BA, PhD	Associate Director
L.C. Godfrey, BSc	Head, Administration
K. Neer,[1] BA, MLS	Librarian

Entomology—Plant Pathology

R.D. McMullen, BSc, MSc, PhD	Head of Section; Bionomics of pear psylla
N.P.D. Angerilli, BSc, PhD	Orchard mite control, San Jose scale
F.L. Banham, BA	Stone fruit insects
V.A. Dyck, BA, MSc, PhD	Management of codling moth
W.J. McPhee, BSc, MSc, PhD	Tree fruit fungus diseases
A.J. Hansen, DipAgr, MSc, PhD	Tree fruit virus diseases
H.F. Madsen, BA, PhD	Apple pest management
J.T. Slykhuis, BSA, MSc, PhD	Stone fruit virus diseases
R.S. Utkhede, BSc(Agric), MSc(Agric), PhD	Tree fruit fungus diseases

Food Processing

D.R. MacGregor, BSA, MS, PhD	Head of Section; Product development, microbiology
H.J.T. Beveridge, BSA, MSc, PhD	Food chemistry and analytical methods
D.B. Cumming, BSA, MSc, PhD	Food technology
G.E. Strachan, BSA, MSc	Enology and food technology

Pomology and Viticulture

E.J. Hogue, BSA, MS, PhD	Head of Section; Herbicides, vegetation management, nutrition
L.G. Denby, BSA, MSA	Viticulture, grape breeding, tree varieties, and training
W.D. Lane, BSc(Agric), MSc, PhD	Apple and cherry breeding
N.E. Looney, BS, MS, PhD	Pomology, plant physiology, growth regulators
M. Meheriuk, BSc, BEd, MSc, PhD	Fruit storage and biochemistry
H.A. Quamme, BSA, MSc, PhD	Orchard management, hardiness
A.G. Reynolds, BSc(Agric), MSc, PhD	Grape management

Soil Science and Agricultural Engineering

D.S. Stevenson, BSA, MS, PhD	Head of Section; Soil moisture
A.P. Gaunce, BSc, MSc, PhD	Pesticide and environmental chemistry
P.B. Hoyt, BSc MS, PhD	Soil chemistry and management
A.L. Moyls, BASc, MS, PhD	Agricultural equipment—development and assessment
G.H. Neilsen, BSc, MSc, PhD	Soil fertility and plant nutrition
P. Parchomchuk,[2] BASc, MS	Agricultural equipment—development and assessment

Departures

D.R. MacGregor, BSA, MS, PhD Retired May 1984	Product development, microbiology
W.J. McPhee, BSc, MSc, PhD Resigned April 1984	Tree fruit fungus diseases
H.F. Madsen, BA, PhD Retired December 1984	Apple pest management

VISITING SCIENTISTS

V.K. Gupta,[3] BSc, MSc, PhD	Entomology
O.L. Lau,[4] BS, MS, PhD	Pomology and viticulture
B.W. Thair,[5] BSc, MSc, PhD	Entomology
K. Tomala,[6] BSc, MS	Pomology and viticulture

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[1]Seconded from Libraries Division, Finance and Administration Branch.
[2]On educational leave, University of California, Davis, Calif.
[3]Under auspices of Food and Agriculture Organization/UNDP, Himachal Pradesh Agricultural University, Solan, India, February–May 1984.
[4]B.C. Tree Fruits Research Associate since July 1976.
[5]On educational leave from College of New Caledonia, September 1984–June 1985.
[6]On transfer of work from Warsaw Agricultural University, Warsaw, Poland, from January 1984–June 1984.

INTRODUCTION

The Summerland Research Station is located in the Okanagan Valley and conducts research directed at solving problems of production and utilization of tree fruits and grape in order to provide high-quality products for the consumer. Substations are located in Kelowna to the north and Creston to the east. At the end of 1984 Dr. H.F. Madsen, Associate Director of the station, retired, and during the year Dr. D.R. MacGregor, Head of the Food Processing Section, retired. Dr. W.J. McPhee, Plant Pathologist, resigned early in the year. This report refers to some of the major research achievements in 1984. More detailed information may be obtained from the publications listed at the end of this report or from individual scientists. Requests for further information or for reprints should be addressed to the Research Station, Research Branch, Agriculture Canada, Summerland, B.C. V0H 1Z0.

G.C. Russell
Director

ENTOMOLOGY—PLANT PATHOLOGY

Apple replant disease

Several pathogenic fungi, including species of *Cylindrocarpon*, *Fusarium*, and *Pythium*, isolated from apple replant soils caused various degrees of stunting of apple seedlings when tested in pasteurized soil. Another fungus, (*Penicillium* sp.), isolated from soil caused increased growth of apple seedlings and was associated with increases in available P and N in the soil. Large numbers of parasitic nematodes were found in some of the apple replant disease soils.

Soil-disinfecting treatments differed in their relative effects for increasing growth of apple seedlings in different apple replant problem soils. This indicates that the organisms, or complexes of organisms, which cause apple replant disease differ in different soils. A system of greenhouse testing is recommended to determine the most effective treatment for each orchard before replanting.

A phosphate fertilizer (11-55-0) causes substantial increase in growth of young apple trees replanted in old orchards. For most rapid reestablishment of apple trees in old orchards, this fertilizer should be used along with the most effective means of soil disinfection for each orchard.

Ribavirin chemotherapy of virus-infected apple meristems

We have previously demonstrated that ribavirin, a guanosine analogue, inhibits the replication of several plant viruses and virus-like agents in woody hosts. In order to test the effect of the compound upon replication of apple chlorotic leaf spot virus (CLSV) in apple meristem cultures, we grew meristems of CLSV-infected Winter Banana apples on media enriched with various levels of ribavirin. Control cultures were grown on the same medium without ribavirin. Meristem shoots were allowed to root and the resulting small trees were planted in the field. Infectivity of CLSV before, during, and after culture on enriched and normal medium were tested by indexing individual shoots on leaves of young *Chenopodium quinoa*. CLSV content of the 3-yr-old field trees was tested by annual indexing of young leaves.

The results show that CLSV-infectivity could not be detected after one generation (4 wk) of growth on media enriched with 10, 20, 40, or 80 ppm of ribavirin. All control shoots retained their infectivity. Phytotoxicity was observed in most shoots exposed to 40 and 80 ppm of ribavirin. Trees obtained from treated shoots were still virus-free after 3 yr in the field.

Meristem cultivation on medium enriched with 10 ppm or 20 ppm ribavirin seems to be a fast and efficient way to produce virus-free trees of apple cultivars infected with CLSV.

Screening world apple germplasm collection for resistance to *Phytophthora cactorum*

Five hundred thirty-five accessions from the U.S. Department of Agriculture world apple germ plasm collection were screened for resistance to *Phytophthora cactorum*, causal agent of apple crown rot. In the laboratory, excised dormant twigs were inoculated with *P. cactorum*. Length of necrosis produced was used as a measure of relative resistance. Sixteen plant introduction lines were very resistant, 50 showed intermediate resistance, and 469 lines were very susceptible to *P. cactorum*. These results indicate a wide range of genetic variation in resistance and suggest the possibility of breeding resistant rootstocks to control the disease.

Chemical control of apple crown rot

Fungicides were applied to 15-yr-old McIntosh and 12-yr-old Red Delicious apple trees on MM106 rootstock in commercial orchards, using a randomized complete block design with five replications. Each treatment consisted of five trees. The fungicides were applied twice a year, May and August, in 4.5 L of water as a drench around the base of the trunk. Original observations on trees showing initial, intermediate, and terminal symptoms of crown rot were recorded in May 1981. Symptoms of crown rot were noted as follows: Initial—about one-quarter of the bark around the trunk infected by *Phytopthora cactorum*; intermediate—about one-half of the bark infected; terminal—more than three-quarters of the bark infected. The number of dead trees and newly infected trees in each treatment was recorded in September 1983.

Metalaxyl, metalaxyl plus mancozeb, and efosite Al all prevented the occurrence of new infections of *P. cactorum* and arrested infections on trees with initial symptoms but not on trees with intermediate and terminal symptoms. These results indicate good promise for these treatments as control measures for crown rot of apple.

Control of an organophosphate resistant population of the fruittree leafroller

Methidathion at either 11.2 or 5.5 L/ha applied to apples at the 15 mm green tip stage of bud development provided good control of a fruittree leafroller population resistant to azinphos-methyl and diazinon. Methidathion kills larvae as they emerge from overwintering eggs and it must be applied prior to egg hatch in the early spring. Methomyl and chlorpyriphos were also effective, but they did not provide as good control over an extended period of egg hatch. The spring of 1984 was unusually cold and wet, resulting in leafroller egg hatch extending over a 6-wk period rather than the normal 3 wk. Under these circumstances, *Bacillus thuringiensis* also failed to provide adequate control. Although methidathion gives good control, the insecticide has the undesirable side affect of promoting increases of phytophagous mites, as it is toxic to the principle mite predators.

Distribution of four species of leafrollers in the Okanagan Valley of British Columbia

The distribution of four species of leafrollers in the Okanagan fruit-growing area was surveyed with sex pheromone traps placed in apple orchards and in native woodland sites. The trap captures indicated that three species, European leafroller, obliquebanded leafroller, and three-lined leafroller are widely distributed both in orchards and in uncultivated areas. Larval samples from native hosts confirmed that these species have a wide host range of cultivated and native trees and shrubs. With this distribution pattern, monitoring of these leafroller populations in orchards is not feasible because the traps also attract moths from hosts outside of the orchards. The fruittree leafroller, however, was mainly recorded from orchards and rarely taken in uncultivated areas. Because this species is endemic to orchards, it may be possible to develop a monitoring program for this leafroller. It is interesting to note that the fruittree leafroller is the only species which has developed resistance to organophosphate insecticides.

Effects of fenoxycarb, a growth regulator on larvae of the fruittree leafroller

In laboratory experiments, fruittree larvae exposed to fenoxycarb failed to develop properly and died either as late instar larvae or as pupae. All larval stages were affected and no treated larvae were able to pupate and emerge as adults. In the field, experiments with fenoxycarb were not as effective. Because conventional evaluation techniques were not applicable, larvae from treated plots were collected and reared in the laboratory on artificial diet to determine mortality. The highest mortality was 66% following a spray 1 wk post-petal fall directed against late instar larvae. Earlier applications resulted in much lower larval mortality. Examination of harvested apples for leafroller injury indicated no difference between any of the treated plots and the untreated control. Although the material may affect the ability of larvae to complete development, it obviously does not prevent them from feeding upon fruit.

Control of San Jose scale with degree-day timed sprays

Accumulated degree-days past 1 March (using temperature thresholds of 10.5°C and 32.5°C) were used to time the application of diazinon sprays having an active ingredient (a.i.) of 50 g/100 L, for control of San Jose crawlers. Sprays were applied at 400, 500, 600, or 700 degree-days after the detection of the first male by pheromone-baited traps. At harvest, the percentage of scale-infested apples in each of the treatments was 0.04, 0.86, 1.24, and 3.44, respectively, compared to 4.65 in the untreated control.

Measuring San Jose scale phenology in two geographic areas

Pheromone-baited traps were less reliable than sticky barrier traps for detecting the emergence of

first generation males. Male emergence as detected by either pheromone traps or sticky barrier traps was not well correlated with tree phenology (cultivar Red Delicious) between geographic areas. In the Summerland area, males began to emerge at the opening of king blossoms, whereas in the Osoyoos area, male emergence began at calyx. The period of male emergence at Osoyoos was compressed compared with Summerland. At Osoyoos, 50% of the male population had emerged by 2 days after calyx, compared with 14 days at Summerland. Degree-day accumulations after 1 March (lower and upper thresholds of 10.5°C and 32.5°C) related to first and 50% emergence were equally variable between areas and would not be reliable indicators of male emergence. The first generation crawler emergence period peaked at about the same number (660–690) of degree-days after 1 March in both areas, although the calendar dates differed by between 6–12 days.

(Z)-11-tetradecanal, an additional component in the pheromone composition of the obliquebanded leafroller in the Okanagan Valley of British Columbia

In 2 yr of previous field studies, the optimum synthetic pheromone blend was determined to be 3 mg (Z)-11-tetradecen-1-yl acetate, (E)-11-tetradecen-1-yl acetate, and (Z)-11-tetradecen-1-ol in a ratio of 96.5:2:1.5 on rubber cap stoppers. However, traps baited with *Choristoneura rosaceana* females were more attractive and the synthetic blend also attracted significant numbers of European leafroller, *Archips rosanus*.

In 1984, the aforementioned blend with 1% (Z)-11-tetradecanal added was significantly more attractive than traps baited with *C. rosaceana* females but *A. rosanus* males were still attracted. Increased percentages of (Z)-11-tetradecanal up to 4% enhanced catches of *C. rosaceana* and reduced the attraction of *A. rosanus*. Two additional components, (E)-11-tetradecanal and (E)-11-tetradecen-1-ol, found in females may also be important in formulating a synthetic pheromone blend specific to males of the Okanagan Valley strain of *C. rosaceana*.

Influence of additional pheromone components on the measurement of disorientation to traps in a codling moth disruption experiment

The disruption plot consisted of a 0.45-ha block of semi-dwarf apple trees treated with 5000 rubber cap stoppers (12 per tree) containing trans 8, trans-10-dodecadien-1-ol to give an estimated pheromone emission rate of 10 mg/ha per hour. Traps containing trans 8, trans-10-dodecadien-1-ol alone or in combination with differing amounts of two additional components, dodecadien-1-al and dodecan-1-ol, were deployed in this orchard and in a similar-sized untreated plot to determine the percentage of disorientation during a 3-mo period of codling moth activity.

Traps with the additional components all captured codling moth males but none of the pheromone component combinations captured significantly more males than the traps baited only with trans 8, trans-10-dodecadien-1-ol. Moth captures in the disruption plot were considerably lower than captures in the untreated control area and the percentage of disorientation averaged 71.4% over 3 mo.

Integrated control of the Virginiacreeper leafhopper

For the fourth consecutive yr, an integrated pest management program continued to provide effective control of the Virginiacreeper leafhopper in two hectare experimental blocks of Foch and Okanagan Riesling grapevines. In 1984 and 1983, both the first and the second generation of leafhoppers were suppressed to noneconomic levels in the perimeter and central core areas of both blocks by the egg parasite, *Anagrus epos* Girault. No insecticide sprays were required in either year. In 1982, one spray of carbaryl having an a.i. of 275 g/ha was applied against the first generation of leafhopper after peak of egg parasite activity. In 1981, a similarly timed spray was required in both blocks plus spot-sprays for second generation leafhopper nymphs and adults in a few heavily infested portions of the perimeter areas. During the 4 yr, egg parasitism for the first generation ranged from 0 to 26.1% and for the second generation 46.3 to 81.5%.

Thrips control in vineyards

At the 80% blossom stage, western flower thrips were controlled in 0.1-ha plots of Foch and Okanagan Riesling grapevines by one spray of dimethoate having an a.i. of 1.0 kg/ha, or deltamethrin having an a.i. of 10 g/ha, applied by hand gun sprayer. These treatments gave an average of 97.3% thrips control on Foch and 80.5 and 75.9% control on Reisling, respectively. Diazinon having an a.i. of 2.25 kg/ha, the current recommendation, was significantly less effective.

In midsummer, a new economic pest on grapes in the Okanagan Valley, tentatively identified as grape thrips, was controlled by a single spray of dimethoate having an a.i. of 1.0 kg/ha in an 8-ha block of Foch and a 4-ha block of Okanagan Reisling grapevines. The population levels of thrips in these blocks were reduced by 99.4 and 99.3%, respectively. Following treatment, there

was no detectable evidence of continuing thrips feeding injury that had caused stunted shoot tip growth, shortened and scarred internodes, and bronzed leaves.

FOOD PROCESSING

Diffusion extraction of juice from apples

Fruit juice production by countercurrent extraction or diffusion is now being practiced in some parts of the world. Yields can be as high as 92–95% of available soluble solids (SS). Resulting "juice" is too dilute (9.5–10% SS) to be considered single strength, fresh apple juice. Normally, the extracted juice goes to concentration for later use in that form. Experiments conducted at Summerland have shown that the process has a number of sensitivities to process parameters including extraction temperature, fruit quality, and slice thickness (apples are sliced, not macerated). When resulting juice was concentrated, reconstituted, canned, and then compared to similarly treated press juice by a semi-trained sensory panel, a number of differences were noted. The major difference observed was that the diffuser juice (Red Delicious) was noticeably more astringent and drying than the press juice. Some differences in perceived sweetness and acidity were noted but were minor. The diffuser juice was a little darker in color than the press juice but this can be controlled. Sensory tests were designed to identify differences between concentrate from diffuser and press processes. Acceptance by consumers was not tested and it remains to be determined whether or not the differences in the diffuser product would affect, either positively or negatively, consumer attitudes. Work is continuing on apple and pear juice production as well as extraction of anthocyanin pigments from grape pomace.

Pear juice production from heated pear mashes

Juice produced from cull pears is normally dark-colored due to polyphenol oxidase activity occurring during milling and pressing operations. In order to produce a high-quality clear, almost colorless juice from pears it is necessary to control polyphenol oxidase. Although chemicals such as ascorbic acid or sulfur dioxide temporarily inhibit the enzyme, the only feasible permanent control is attained through thermal denaturation of the enzyme. However, when fruit mashes or press juices are heated sufficiently to assure enzyme control, the resulting juices become difficult to clarify by conventional means.

A procedure has been described for producing a clear, colorless, or light golden pear juice from fresh, ripe, or cull fruit mashes heated to provide polyphenol oxidase control. Whole pears are mashed in the presence of an antioxidant such as sulfur dioxide or ascorbic acid, then thermally treated at 90°C for 20 s in a scraped surface heat exchanger and cooled rapidly. The thermized mash is enzymatically digested with pectinase and the juice is obtained by passage through a decanting centrifuge operating at 2500–3000 g. The resulting cloudy juice (yields 75–85%) is digested enzymatically with a cellulase. The flocculent precipitate is settled and the clear supernatent used as juice. A brilliantly clear juice may be obtained by a final filtration. A clear, light-colored juice suitable for concentration is obtained, its exact color and flavor depending upon fruit condition and maturity. If the pears are fully ripened, the juice carries the full pear flavor.

POMOLOGY AND VITICULTURE

Chemical thinning of apples

Greater precision in reducing the crop load on apple trees with "chemical thinning" agents is being achieved because of new knowledge about the relationship between blossom density and natural fruit set; the relationship between "initial" set and final fruit set; the effects of spray volume on the amount of thinning that will be achieved; and the benefits of combining chemicals to achieve greater thinning activity. With the spartan variety, a 3-yr experiment showed that combining carbaryl with naphthaleneacetic acid (NAA) in a single spray applied 15 days after full bloom resulted in near optimal fruit thinning; that this combination spray was effective even when applied as a "concentrate" spray at water volumes as low as 560 L/ha; and that trees with a heavy bloom were most easily thinned with this treatment. Spartan apple trees flower primarily on spur shoots and the bloom period at Summerland is very condensed. Another variety, Greensleeves, flowers on 1-yr wood as well as on spurs and the bloom period is much longer. Experiments with this variety showed that young fruits developing on 1-yr wood are easily thinned with carbaryl and that the number of fruits that appear to be set at 15 days (initial set) is inversely related to final set. Furthermore, final set following a carbaryl spray applied to either spur- or 1-yr-clusters is highest on those spurs with only one or two initially set fruits.

Quality aspects of Bartlett pears thinned chemically and by hand

Quality aspects of Bartlett pears from trees thinned by hand or thinned chemically with naphthaleneacetamide (NAD) (having an a.i. of 44 g/ha) were investigated at harvest and after cold storage in each of four consecutive seasons. Fruit firmness values at harvest and after cold storage were slightly reduced by the NAD treatment but SS and titratable acidity were unaffected. In one season, the NAD-thinned pears were slightly yellower at harvest and at harvest plus 7 days at 20°C, and in another season the fruit had a slightly higher incidence of core browning after 60 days of −0.5°C storage plus an additional 10 days at 20°C. However, none of the effects were of sufficient magnitude to be of commercial significance.

Crop control of French–American hybrids and *Vitis vinifera*

Investigations into the influence of cluster thinning, shoot thinning, and base shoot removal have been established on cultivars Seyval blanc, de Chaunac, and Riesling clone 21B. Cluster thinning to one cluster per shoot increased cluster weight, berries per cluster, and weight per berry, as well as yield per vine over unthinned controls. A slight benefit of shoot thinning was seen in terms of yield components as well. Both practices improved fruit quality, as expressed by a Brix scale. Experiments were initiated in 1984, and these results constitute those of the 1st yr of a multi-season trial.

Mechanized pruning of the cultivar Okanagan Riesling

Okanagan Riesling vines were trained to three systems (midwire cordon, Hudson River umbrella, and Lenz Moser) and subjected to either manual balanced pruning or mechanical pruning. Mechanically pruned vines yielded significantly higher than manually balanced pruned vines without any attendant loss in fruit quality. Effects of training have not been assessed. Results are those of the 1st yr of a multi-season trial.

Influence of paclobutrazol (ICI PP-333) on the suppression of growth of summer laterals and trunk suckers

Paclobutrazol (ICI PP-333), an inhibitor of gibberellin biosynthesis, was applied at 500 ppm during Stage I of berry development of both summer-pruned and non-summer-pruned 4-yr-old Riesling cultivar vines (clone 21B). Growth of summer laterals of the top five nodes of each shoot was significantly restricted by PP-333 in both summer-pruned and intact vines compared with water-sprayed controls. No effect on yield or quality was apparent. Paclobutrazol applied at 250 and 500 ppm in latex to trunks and arms of recently suckered Okanagan Riesling vines led to an inhibition of sucker regrowth compared with latex controls when observed in late August. Inhibition was comparable to other treatments containing both 1% and 2% NAA in latex. No yield or fruit quality inhibition by either growth regulator was evident. Results of both experiments constitute those of the 1st yr in a multi-season trial.

Sweet cherry breeding

A number of cherry selections have performed well for several years in succession and have now been propagated for further testing. The following descriptions indicate their most important characteristics.

Very early

13S-24-28: Van × (Van × Stella)—self-fertile, very resistant to splitting, ripens 3–6 days before Van, large fruit (10–12 g), good crops, firm, attractive, good taste. This has been our best selection for several years, including this season.

Early

13S-18-15: (Star × Van) × (Van × Stella)—self-fertile, very split-resistant, large fruit size (10–11 g), good crops, attractive, and firm. Ripens with Van.

13S-10-40: (Star × Van) × (Van × Stella)—self-fertile, very split-resistant, large fruit size (10–12 g), consistently heavy crops, round-shaped fruit, attractive and firm, with thick stems. Ripens with Van.

Late

13S-39-51: Van × (Van × Lambert) × (Bing × Salmo)—not self-fertile, very large fruit (12–15 g), very good taste, skin color remains red and flesh white to pink, very attractive, light crops so far but equivalent to Summit in size and yield. This selection is very promising because of fruit size, distinctive appearance, and good taste. It appears to be split-resistant. Ripens with Lambert.

13S-17-40: (Star × Van) × (Van × Stella)—self-fertile, split-resistant, fruit size (10–12 g), skin not fully black, attractive, consistent crops, medium firm. Ripens slightly before Lambert.

2S-36-36: (Compact Lambert × Van) × Stella—self-fertile, large fruit size (11–13 g), very round shape, medium firm, taste good but not too sweet. Ripens with Stella.

13S-22-8: Van × (Van × Stella)—self-fertile, very late maturing 5–10 days after Lambert. Consistently good crops, attractive, very firm. The fruit has a good flavor and is medium to large (10–11 g).

White flesh

13S-15-15: Van × Stella—self-fertile, consistent high yields, attractive, firm, low acid, and sweet taste. Fruit weight is medium (9–10 g).

13N-10-1: Stella × Stella 35A—compatibility reaction unknown, late maturing. This selection has white flesh fruit but with dark red skin, which hides bruises and scuff marks. The fruit is very firm, very good tasting, and is medium to small (8–10 g). This is a promising new type because of its flesh and skin colors.

Dwarf

13S-17-15: (Star × Van) × (Van × Stella)—self-fertile, spurry, dwarf tree, good crops, and medium to large fruit size (about 10 g) but prominent suture. Ripens several days before Lambert.

4C-17-31: Semi-dwarf tree with close internodes that prevent sunburn of fruit. The fruit is medium in size, moderately split-resistant, and the tree bears consistently good crops. Ripens in mid-season. This is a promising selection for hot growing areas.

Apple breeding

The following apple selections are of good quality and have been of interest to commercial growers and nursery operators. All have yields and fruit size equivalent to commercial cultivars in the same season.

9F-22-42: Very early red apple with bright white flesh and very good taste for the season. Ripens the 1st wk in August with the latest cherry selections. Size and yield better than other varieties in this season; very promising.

8C-1-15: Similar in appearance to Granny Smith but ripens in the 1st wk of September. The taste is good but not identical to Granny Smith. Productivity and size should be good, since McIntosh and Golden Delicious are close ancestors. Probably our best early Granny.

8B-20-73: Very large golden type of apple maturing in the 1st wk of September. Firmness and quality are nearly as good as Golden. It could be considered an Early Matsu.

8C-21-31: A large, good-tasting apple with a bold dark red stripe on light background. It is different in appearance than most commercial cultivars, and is smooth, uniform, and attractive. It ripens shortly after McIntosh.

8C-28-27: Similar to Red Delicious but is rosy red rather than dark red and has better storage characteristics and flavor than Red Delicious. It is about equal in firmness and ripens about 10 days before Red Delicious. Promising as an improved Red Delicious, especially for late areas.

8M-35-17: Very large, dense, rosy red apple with exceptionally good taste. Very uniform, smooth shape without high sheen. Similar to Jonathan in flavor but larger and firmer. Possibly a tripoloid.

8M-15-10: Very large, smoothly shaped apple with dense flesh and exceptionally good flavor. Light red stripe on most of the apple makes it distinctive-looking (rather like a peach) and attractive to many of those who have examined it. Equivalent in many respects to Jonagold but firmer and with less red color. Ripens about the same time as Jonagold.

9C-27-96: Large elongated apple somewhat similar to Red Delicious in shape. Color is rosy red stripe on a light background. The fruit is large, and very good-tasting, and very juicy. Ripens in early September. Promising because of its attractive distinctive appearance and good taste but does not store too well.

SOIL SCIENCE AND AGRICULTURAL ENGINEERING

Grape production as influenced by ground cover treatment

In the third season of Foch grape production, yields were 3.0, 7.1, and 8.6 kg per grapevine for grass, herbicide, and plastic mulch ground cover treatments, respectively. These mean yields are independent of nitrogen fertilizer treatments. Irrigation via the trickle method has been uniform over all treatments. The only change of yields from 1983 to 1984 was that the herbicide treatment no longer differed significantly from the plastic mulch treatment, although the yield still tended to be lower than that under the plastic. As in past years foliage color, as measured visually, was a progressively darker green in the order of grass, herbicide, and plastic mulch, respectively, but it was completely independent of nitrogen treatments. Correlation of this color with subsequent yields was again good.

Although increased in 1984 from 25, 50, and 75 kg/ha to 50, 100, and 150 kg/ha, nitrogen fertilizer again had no effect on yields. The independent mean yields were 6.0, 6.2, and 6.3 kg per grapevine for the three N treatments, respectively. The nitrogen treatments again had no measurable effect on foliage color. These 3-yr results confirm a strong competitive effect of grass ground cover on the production of grapes, an

effect that is apparently not related to nitrogen nutrition. The effect may be one of competition for water or for nutrients other than N. It may be a soil temperature or heat effect or it may be some unknown allelopathic effect of the grass. Whatever the cause, grapevines obviously produce much better without vegetative ground cover than with it. Elimination of the ground cover with plastic mulch seemed to have been the most favorable but that may not be a lasting advantage over herbicides. Cultivation may be another alternative.

Vegetable responses to irrigation with sewage lagoon effluent compared with water from wells

In 1983, the Town of Osoyoos, B.C., began testing lagooned sewage effluent for irrigation of tree fruits, grapes, and vegetables. Agriculture Canada personnel at Summerland have assisted with setting up the tests and monitoring the results. Although some differences in the performance of the young trees and grapevines have been noted, the only data to report so far are from the vegetable plots. Irrigation is by the trickle method.

For comparative purposes the following yields are for lagoon water first, well water second. In 1983, tomato yields were 171 and 117 kg per plot; onion yields were 8.8 and 7.2 kg per plot. In 1984, yields in kilograms per plot were as follows: tomatoes 69 and 47, onions 8.6 and 6.7, sweet corn 6.0 and 3.6, green peppers 4.7 and 2.5, cucumbers 40 and 20, and greenbeans 2.8 and 3.4. All of the differences were statistically significant except for the green beans in 1984.

Other than the two kinds of irrigation water, no treatments were imposed upon the plots and each vegetable crop was cultured according to the B.C. Vegetable Production Guide, including fertilizers in the spring. From these results the effluent water appears to provide sustaining nutrition, probably mainly in the form of nitrogen. The longer the season to harvest the greater the spread of yields as exemplified by the tomatoes and cucumbers. The early harvested green beans showed no spread at all.

The results indicate that probably the obvious advantage of the effluent water could be overcome with a suitable fertility program, but there is little doubt that the nutrients carried in the effluent water have considerable value. That value apparently varies with the type of vegetable.

Field comparisons of foliar magnesium sprays on apple trees

Field experiments were performed in 1981 and 1982 to compare foliar application of chelated and Epsom salt–Mg sprays to Delicious apple trees (Red King and Starking strains) and to McIntosh apple trees. The amount of Mg applied in foliar sprays was the key to the improvement of the Mg nutrition of McIntosh apple trees with marginal Mg levels. In 1981, Mg at the label-recommended application rate of 2 × 0.56 kg/ha for the chelated-Mg forms was inadequate. Application of chelated Mg at five times the 1981 rate (one-half the recommended Epsom salt rate) resulted in an adequate leaf-Mg increase for McIntosh apple trees in 1982 in the orchard tested. However, effective rates of Epsom salts were less expensive to apply. (In April 1982 in British Columbia, Mg in the chelated form was about 11 times the cost per unit weight of Mg of Epsom salts). Foliar application of Mg when leaf-Mg concentrations are adequate, as occurred for Delicious apple trees in these experiments, may improve leaf-Mg concentration but does not result in additional extension growth.

The effect of orchard floor management and nitrogen fertilization on Golden Delicious apple trees

For 3 yr mature Golden Delicious apple trees have been subjected to factorial combinations of three rates of N fertilization (30, 60, or 180 kg/ha) applied annually as NH_4NO_3 in April and to three degrees of orchard floor management. The three levels of floor vegetation included sod mowed once in June, vegetation eliminated until July, and vegetation eliminated year-round. Tree N nutrition was affected more by vegetation management than by rate of N fertilizer applied. Significant reduction in leaf N and trunk diameter, and superior fruit skin color and firmness at commercial harvest occurred consistently when the orchard floor was sod. In contrast, increased leaf N and reduced fruit skin color and firmness at harvest were measured at an N rate of 180 kg/ha per year in only 1 yr, whereas the growth was not increased by this rate of N. Increased fruit Ca associated with smaller fruit and increased leaf Mg and leaf K were measured under sod in 2 of 3 yr. Leaf Mn was affected only by rate of N fertilization and was consistently high at an N rate of 180 kg/ha.

Fruit drying

Techniques of increasing the drying rate and uniformity in two commercial fruit leather dryers were investigated. Drying rate was improved by streamlining the inside of the dryer, increasing the blower speed, and operating at elevated temperatures during the initial part of the run. Uniformity was improved by installing a perforated plate upstream of the tray rack. Drying time improve-

ments were from 8 h down to 6.8 h to produce thin fruit leathers and from 14 h down to 12.5 h to produce thick leathers.

Tree injection

Previous experiments showed that pressurized trunk injection of calcium solutions had very little effect on increasing the calcium content of apples, but did cause leaf burning and fruit abcission. However, injections with tetracycline hydrochloride and with water alone were successful in halting the symptoms of pear decline in a commercial orchard. More pear decline trees were injected in the fall of 1984 as well as cherry and apricot trees suspected of being afflicted with a similar mycoplasm.

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Research Station, Vancouver, British Columbia

PROFESSIONAL STAFF

M. Weintraub, BA, PhD, FNYAS	Director
A.R. Forbes,[1] BA, MS, PhD, FESC	Assistant Director
C.A. Gray, BComm	Administrative Officer

Scientific Support

T. Matsumoto,[2] BSA, MSc, MLS	Librarian

Statistical Services

J.W. Hall, MSc, PhD	Regional Statistician

Entomology

A.R. Forbes, BA, MS, PhD, FESC	Head of Section; Virus vectors
B.D. Frazer, BSc, PhD	Aphid ecology
J. Raine, BSA, MS	Berry insects, leafhopper vectors
D.A. Raworth, BSc, PhD	Biological control
S.Y.S. Szeto, BSc, MSc	Pesticide chemistry
D.A. Theilmann,[3] BSc, MSc	Insect virology
R.S. Vernon, BSc, MPM, PhD	Vegetable insects
A.T.S. Wilkinson, BSA	Soil insects, biological control of weeds

Plant Pathology

R. Stace-Smith, BSA, PhD, FAPS	Head of Section; Raspberry viruses, virus characterization
H.A. Daubeny, BSA, MSA, PhD	Plant breeding, small fruits
S.H. De Boer,[4] BSc, MSc, PhD	Bacterial diseases
P.J. Ellis,[5] BSc, BSc(Hons), MPM	Potato viruses
R.R. Martin, BS, PhD	Strawberry viruses
H.S. Pepin, BSA, MA, PhD	Root rots, red stele of strawberry
T.C. Vrain, DEA, PhD	Nematology
N.S. Wright, BSA, MSA, PhD	Potato diseases, serology

Virus Chemistry and Physiology

H.W.J. Ragetli, Ir, PhD	Head of Section; Chemistry and ultrastructural cytopathology of viruses
R.I. Hamilton, BSc, MSc, PhD	Virology, virus interaction and seed transmission
G.G. Jacoli, BA, PhD	Biochemical virology
D.A. Rochon,[6] BA, MSc	Plant viruses, molecular biology
J.H. Tremaine, BSc, MSc, PhD	Biophysical virology
M. Weintraub, BA, PhD, FNYAS	Cytopathology, electron microscopy

Departure

W.T. Cram, BSA, MS, PhD Retired 27 July 1984	Strawberry insects

VISITING SCIENTISTS

R. Credi, PhD University of Bologna, Italy	Plant virology, grape viruses
D.J. Donnelly, BSc(Agr), MSc, PhD Postdoctorate fellow, 1 July 84 to 30 June 86	Plant tissue culture
A. Kurppa, BSc, PhD Agricultural Research Centre, Jokioinen, Finland	Plant virology, molecular virology
S. Kurppa, BSc, MSc Agricultural Research Centre, Jokioinen, Finland	Nematology
S. Marco, BSc, MSc, PhD Volcani Institute, Bet Dagan, Israel	Plant virology, potato viruses
B.C.S. Sutton, BSc(Hons), PhD Postdoctorate fellow, 1 October 84 to 30 September 85	Molecular plant pathology

Honorary Research Associate and Editor

F.C. Mellor, BSA	Virus eradication

Graduate students

S. Barnabe, BEd, MSc	Entomology
T. Baumann, BSc	Plant pathology
H. Contant, MSc	Entomology
K. Giles, BSc	Entomology
R.C. Johnson, BSA	Plant pathology
G. Kalmar, BSc	Virus chemistry and physiology
B. Lyons, MSc	Entomology
R.B. Smith, MSc	Entomology
P. Therrien, MSc	Entomology
J. Walker, BSc	Nematology

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[1]Effective 22 December 1984.
[2]Seconded from Libraries Division, Finance and Administration Branch.
[3]Educational leave, Texas A and M University.
[4]Transfer of work, 1 June 84 to 31 May 85, at Research Institute for Plant Protection, Wageningen, The Netherlands.
[5]Educational leave, University of British Columbia.
[6]Educational leave, Wayne State University.

INTRODUCTION

This 22nd annual report of the Vancouver Research Station summarizes aspects of our dual function, as national center for plant virus research, and responsibility for solving regional problems in plant pathology and entomology.

Biotechnology is a natural outcome of the virus research. Our thrust into this field has resulted in assembly of the largest and most effective group in Canada engaged in biotechnological research in plant health and protection. The results have already been scientifically and economically significant in the production of hybridomas that secrete monoclonal antibodies for detection of a number of plant viruses and of potato bacterial ringrot. Several of these are in process of being licensed to the private sector for marketing.

The integrated pest management program has also begun to yield results in establishing programs to monitor for specific pests of onions, carrots, and potatoes. Determining the pest population permits fewer pesticide sprays with considerable decrease in costs and in environmental pollution.

Further details of research, or reprints of this report or the publications listed can be obtained from the scientists or the Research Station, Agriculture Canada, 6660 N.W. Marine Drive, Vancouver, B.C. V6T 1X2.

M. Weintraub
Director

VIRUS CHEMISTRY AND PHYSIOLOGY

Biotechnology

The ds-cDNA to potato spindle tuber viroid (PSTV) was prepared, inserted into plasmid PUC13, and introduced into competent *Escherichia coli* 7902. Transformed colonies were isolated and amplified, the bacterial cells ruptured to free the plasmids, and the inserted cDNA to PSTV excised and purified. An evaluation of the cDNA inserts for their potential as PSTV probes has yielded seven promising clones. Tests to establish optimal conditions for hybridization of PSTV and the homologous cDNA inserts are in progress.

The number of monoclonal antibody isolates against the type strain of southern bean mosaic virus (SBMV-B) was increased from eight (see Report 1982) to 11. All 11 reacted strongly with dissociated homologous virus protein in the enzyme-linked immunosorbent assay (ELISA) test, six reacted strongly with the native virion in this test and of those, three precipitated the native virion in the gel diffusion test. One of these three also reacted with the virion of the cowpea strain, but this precipitate was dissociated at pH 4 as opposed to 2.5 for the homologous strain, indicating a low affinity. None of the 11 antibodies precipitated homologous dissociated virus protein in the gel diffusion test; all 11 readily precipitated this protein adsorbed to latex spheres.

Physical, chemical, and serological properties of viruses in vitro

The capsid protein subunits of the selected potyviruses tobacco etch (TEV), pepper mottle (PeMV), soybean mosaic, and watermelon mosaic 1 and 2 were studied after limited proteolysis in situ. The molecular weights of the protein subunits of these five viruses, estimated by sodium dodecyl sulfate-polyacrylamide gel electrophoresis, were 32–35 kilodaltons (kd) before, and 26–29 kd after proteolysis. Amino acid analyses of nonproteolyzed and proteolyzed viral capsid protein for each virus showed that the cleaved portion of the subunit (ca 6 kd) had a high content of lysine. Electrophoresis of the capsid proteins of TEV cleaved by cyanogen bromide revealed the loss of two peptides after the limited proteolysis. Reaction of TEV with 2,4,5-trinitrobenzenesulfonate, before and after limited proteolysis, indicated that at least six lysyl residues per protein subunit were lost during the limited proteolysis. Serological tests indicated that some serological determinants are lost after limited proteolysis of TEV and PeMV.

Two strains of carnation ringspot virus, CRSV-R and CRSV-N, aggregated and disaggregated in a temperature-reversible manner at pH 5.0. Aggregated virions sedimenting at 300–1 300 S and 105 S were observed in a CRSV-R preparation (9.5 mg/mL) in the analytical ultracentrifuge at 31–40°C, but they were absent after cooling to 18°C. Electron microscopy of CRSV-R prepara-

tions (0.1 mg/mL) heated to 70°C showed small structured aggregates and large unstructured aggregates. The temperature of aggregation for each strain was inversely proportional to the logarithm of virus concentration. At high concentrations (4 mg/mL), the N strain required higher temperature for aggregation than the R strain, but the requirement was reversed at lower concentrations (0.2 mg/mL). The serological properties and amino acid compositions of the two strains were similar but not identical.

Virus infection

An unusually high molecular weight dsRNA was found in apparently virus-free plants of the bean cultivar Black Turtle Soup. All attempts to transmit a virus from Black Turtle Soup to other plants, including several bean cultivars, failed. No virus-like particles could be detected in Black Turtle Soup or in plants inoculated with the dsRNA or other nucleic acids from this cultivar, and no high molecular weight dsRNAs have been found in other commonly used bean cultivars. The fact that the Black Turtle Soup dsRNA was detected by a method commonly used to screen plants for viral RNAs, e.g., in certification programs, suggests caution in the interpretation of such assays for the presence of virus-specific dsRNAs in plants.

Direct evidence for the presence of virus receptors in the epidermal outer cell wall of leaves was obtained by their sensitivity to proteinase-K applied to intact leaves. Since this effect was based on enzyme action and not blocking of active sites, these results revealed for the first time the protein nature of the receptor sites.

Biological properties of viruses

The preparation of powdered inocula from virus-diseased plant material and their subsequent storage at − 18°C, reported in Report 1973, has eliminated the need for maintaining virus isolates in vivo. Powder inocula of 39 different viruses, 8 additional virus strains, and 1 viroid have been prepared and stored without loss of virulence. Among these are such labile viruses as the hypertrophic mitochondrial virus (still virulent after 9.5 yr); tomato spotted wilt virus (8 yr), cauliflower mosaic virus (8 yr); potato virus Y (5 yr); cucumber mosaic virus (4 yr), and the potato spindle tuber viroid (10 yr).

Ultrastructural responses to virus infections

Arctium minus (common burdock) naturally infected with two unknown viruses, a PVX-like virus (modal length 525–550 nm) and a spherical virus (diam. 23 nm) showed in situ aggregates of virus rods, large degenerated mitochondria (≥1 μm) with few cristae, and hypertrophied osmiophilic chloroplast bodies. Tobacco infected with the spherical virus alone also showed large mitochondria with loss of cristae and hypertrophied chloroplast bodies; *Gomphrena globosa* infected with the rod-like virus only, showed elongated virus particles in the cytoplasm enclosed in tubules with a diameter of 59 nm.

Plantago lanceolata from the field, with leaves showing yellow bands or streaks parallel to the midvein, or with chlorotic mottle, contained a flexuous rod-like virus of modal length 475–500 nm. Cells in the chlorotic areas contained small groups of virions, which appeared "doubly" coated, the outer coat stretching to 17–18 nm from the center. Chloroplasts in the affected areas were without grana and the few thylakoid membranes present were vesiculated; mitochondria showed much reduced numbers of cristae.

Thin sections of leaves of *Lychnis alba* systemically infected with lychnis potexvirus (LPV) and lychnis tobamovirus (LTV) in natural and artificial mixed infection and in artificial single infection did not show significant cytopathology. Virions of LTV, but not of LPV, were seen in plasmodesmata in single and mixed infection. Both viruses were readily detected in the cytoplasm, frequently as aggregates, but LPV appeared to be more abundant in cells of double infected plants.

Virus transmission by seed and pollen

Prunus necrotic ringspot virus (PNRSV), identified by ELISA, was detected in the washes of five of six samples of sweet cherry pollen collected by bees. Infective virus was recovered from two of these samples, one of which was negative by ELISA. No infective virus was detected in washes of pollen from raspberry or forage legumes.

Electron microscopy of thin sections of pollinia from *Cymbidium* and *Cattleya* species infected, respectively, with ondontoglossum ringspot virus (ORSV) and cymbidium mosaic virus (CyMV) showed that about 10% of the pollen grains in the ORSV-infected orchids were infected whereas less than 1% of those from the CyMV-infected orchids contained visible virions. Virons of both viruses were detected in leaves of orchids infected with these viruses but none was found in leaves or pollinia of an apparently virus-free orchid.

Little cherry disease (LCD)

Light-skinned sweet cherry cultivars have received little attention in LCD studies, because fruit symptoms would be inconspicuous and few

such orchard trees are still in production. Electron microscopy of leaf petiole tissue from a large orchard tree, cultivar Royal Ann, having small, pointed fruit revealed the characteristic cellular inclusions in the EM, viz., rods and vesicles, associated with LCD.

During the extraction and isolation procedure for LCD-associated virus-like particles, vesicular inclusions, also associated with the disease, were collected in the P27,000 pellet. Angular vesicles of 70–100 nm diameter were subsequently obtained in more pure and concentrated form following sucrose density centrifugation.

Dodder parasitizing LCD-infected cherry was found to be a good source of LCD-associated dsRNAs; similar electrophresis patterns were obtained from cherry and dodder.

PLANT PATHOLOGY

Virology

Double-stranded RNA (dsRNA) was purified from raspberry infected with raspberry bushy dwarf virus (RBDV), black raspberry necrosis virus (BRNV), raspberry leaf spot virus (RLSV), and tomato ringspot virus (TomRSV), and from loganberry exhibiting calico symptoms. The dsRNA isolated from RBDV-infected *Chenopodium quinoa* and TomRSV-infected *Nicotiana clevelandii* co-migrated with the corresponding dsRNAs isolated from *Rubus*. Samples from declining raspberry fields usually contained dsRNA bands of more than one virus. Several field samples contained dsRNA bands of the aphid-borne viruses RLSV and BRNV. The dsRNA bands isolated from loganberry with calico symptoms co-migrated with the dsRNAs of TomRSV, suggesting that a nepovirus may be responsible for the calico symptoms in loganberry.

Raspberry bushy dwarf virus antisera produced in rabbits have not been useable for ELISA testing, due to high background reactions. Monoclonal and polyclonal sera were compared in field tests for the detection of RBDV. With the best polyclonal serum available there was about a 5% overlap between the infected and healthy samples, whereas with the monoclonal antiserum the healthy and infected samples yielded two distinct populations. One advantage of using monoclonal antibodies is that supposedly a single conjugate (i.e., goat anti-mouse peroxidase) can be used in many different virus-antibody systems.

Thimbleberry, *Rubus parviflorus*, is a common native shrub in coastal British Columbia. In the spring of 1983 a plant showing chlorotic marking along the leaf veins was indexed by sap-transmission to a range of test hosts. Most of the inoculated plants showed no symptoms, but one species, *Chenopodium quinoa*, became infected. Serological tests with sap from the infected *C. quinoa*, showed the virus to be a strain of RBDV. A survey involving more than 400 thimbleberry plants from many sites in the Fraser Valley showed that the virus is prevalent throughout the valley. Evidence suggests that the virus is endemic in the native thimbleberry. It sometimes occurs in commercial red raspberry, but its spread from thimbleberry to red raspberry has been limited.

Virus-free potatoes

The Vancouver Research Station has devised a strategy to control potato virus X (PVX) and potato virus S (PVS). Virus-free clones of the required cultivars were developed by heat therapy and tissue culture propagation of meristem tips from the treated plants. Virus-infected seed stocks in the Pemberton and Cariboo Seed Potato Control Areas were gradually replaced by virus-free ones.

Since both viruses are readily rub-transmissible, contamination was common at first. However, by using extreme sanitary precautions, including long rotations, and by utilizing the "flush-out" feature, which is implicit in the Canadian Elite Seed program, PVX and PVS have been almost totally eradicated from Pemberton and from three out of four seed farms in the Cariboo.

It is evident that by using seed potatoes which are free from PVX and PVS and by avoiding contact with diseased ones controlling these viruses is quite feasible. The industry will continue to rely on the seed control areas for seed that is free from the aphid-borne viruses and, before long, all potatoes grown in British Columbia should be free from PVX and PVS.

Small fruits

Strawberry. Evaluation of each new seedling selection requires a large number of plants. Rapid multiplication can be achieved by micropropagation: the propagation of small aerial cuttings in sterile nutrient culture. Six new strawberry selections and the strawberry cultivar Totem are being propagated in vitro at the Vancouver Research Station. The propagules will be evaluated both in culture and after transplanting to soil. Some are expected to be included in field trials next summer.

Raspberry. Recent expansion of fresh market outlets for British Columbia red raspberries emphasizes the importance of selecting for post-

harvest fruit rot resistance in the breeding program. Among the commercial cultivars in the Pacific Northwest, Nootka has become the standard for resistance, but it is not particularly well suited to the fresh market because of soft, dark, and relatively small fruit. Two other selections from the breeding program are promising. 74-10-81, which is now being propagated for wide-scale commercial testing, showed as much resistance to post-harvest fruit rot as Nootka and is considered much superior for fresh market because of its relatively large, firm fruit, which are bright, glossy red. 74-12-42, now being propagated for wide-scale commercial testing, showed less resistance to post-harvest rot than Nootka, but it was comparable in reaction to Skeena, Chilcotin, and Meeker. This selection and these three cultivars all produce fruit of better quality than Nootka for the fresh market. All of the aforementioned cultivars and selections showed considerably more resistance than Willamette, the long-established commercial cultivar in the Pacific Northwest.

Bacteriology

Five monoclonal antibodies to bacterial ring rot pathogen II are currently under review. A variety of diagnostic procedures are being evaluated for each antibody. These procedures include immunofluorescence, latex agglutination, double diffusion, and ELISA. Preliminary evidence shows that each antibody possesses unique characteristics that make its suitability as a diagnostic measure dependent on the procedure selected. In addition, by combining two or more antibodies, increased confidence can be placed on a positive result. Continued effort, both in the laboratory and in the field, should result in unequivocally identifying the pathogen in the near future.

Nematology

Concern over the incidence of crown gall, caused by *Agrobacterium tumefasciens*, on raspberry roots and canes is increasing in the lower mainland of British Columbia. The disease is noticed more often on a recently introduced cultivar, Skeena, than on the long-established cultivar, Willamette. In a recent survey, high nematode densities were commonly found in roots of crown gall-infected plants. Nematode infection increases the number of galls on both cultivars, but Skeena roots harbor many more galls than do Willamette roots. In the early stages after inoculation, the bacteria increase root weight, mostly through development of galls, and nematodes and bacteria have no more effect on cane and foliage weight development than either pathogen alone.

A survey of Okanagan orchards was conducted in 1984 to determine whether nematodes are involved in decline of young trees. Species of plant parasitic nematodes and their densities were determined from 390 samples of tree roots and rhizosphere soil around poorly growing trees and vigorous trees. Ten genera of plant parasitic nematodes were identified, but most of them were found in only a few samples and in low densities. However, in 64 samples, root-lesion nematode densities were above 300 per 200 cm^3 of soil or per gram of fresh root weight. This level has been shown experimentally to cause significant stunting and root necrosis of seedlings growing in unsterilized soil.

ENTOMOLOGY

Vectors

Little cherry disease (LCD). Electron microscopic inclusions and red-leaf symptoms, both indicative of LCD, were induced in 10 of 12 Sam cultivar indicator trees by the apple mealybug, *Phenacoccus aceris* (Signoret).

Strawberry aphids. A ladybird beetle, *Coccinella septempunctata* Linnaeus, was introduced in small numbers from Nova Scotia to a strawbery field as a natural control agent of aphids. This beetle has been introduced in other parts of North America and is established in Nova Scotia.

Aphid survey. New records brought the number of known aphid species in British Columbia to 357. Aphids have now been collected from 786 different host plants and the total number of aphid–host associations is 1484.

To reevaluate the threat of virus transmission in potential seed potato areas, a trapping program was initiated in the Fraser Valley to monitor for the green peach aphid, *Myzus persicae* (Sulzer), the principal vector of potato leaf roll virus. Based on trap results it was possible to delay the top kill date several weeks this year. Poor growth due to the cool spring would have resulted in very low yields had top kill dates not been delayed.

Pest control

Pests of small fruits. The growth and yield of Totem cultivar strawberries and the population fluctuations of the twospotted spider mite, *Tetranychus urticae* Koch, and its predators were determined at four relative initial densities of *T.*

urticae (0:1:3:9). Yield was accurately predicted (R = 0.988, 12df) by three variables: number of flowering stalks; accumulated mite-days from 15 May to the end of harvest; and mites/leaflet on 15 May. Field plots with 25 mites/leaflet 1 wk before harvest produced 9% less than the controls, which represents a loss of $1100/ha. Losses were smaller in field plots with 26–42 mites/leaflet 1 wk before harvest, probably because the plants had time to compensate for mite feeding by producing more mature leaves prior to fruit set. Mite densities observed in this experiment were well within the normal levels found commercially. The economic threshold of 4.8 mites/leaflet 1 wk before harvest was close to the current estimated economic threshold of five mites/leaflet.

The use of a sex pheromone in field traps for the blackheaded fireworm *Rhopobata unipunctana* (Haworth), a serious pest of cranberry, proved successful. The use of this pheromone in traps will aid in more accurate monitoring of this pest, and more judicious use of insecticides to control it.

In field tests, three applications of the following sprays gave effective control of eight species of leafrollers on blueberry: Diazinon 50 EC at 2.5 L/ha; Sevin XLR43LS at 2.3 or 3.0 L/ha; Decis 2.5 EC at 0.2 L/ha; or Dylox 4LS at 2.75 L/ha. Malathion 50 EC at either 2.5 or 3.0 L/ha gave variable results in the spring when temperatures were low but it was effective later in the season when it was warmer.

Onion maggot. Cardboard traps painted 48 chromatic or achromatic hues were used in an onion field to study the color preference of the onion fly, *Delia antiqua* (Meigen). White was always among the most attractive colors tested. Violet and blue were as attractive as white, and significantly more attractive than other colors with peak wavelength reflectance of 480–700 nm. Yellow, the color used in most North American onion fly monitoring programs, was a very poor attractant. White traps were used to determine the most appropriate shape, size, height, direction, field position, number per hectare, and duration of field exposure. The trap and the trapping procedure developed are 80% more efficient than the ones used previously.

Tuber flea beetle. Methods were developed to accurately monitor populations of tuber flea beetle, *Epitrix tuberis* Gentner, in potatoes. The efficiency of visual and sweep-net sampling methods was determined over a wide range of field conditions. Other studies included distribution of these beetles in fields, how far they move, and how much damage a given number can cause. The sampling procedures developed will enable field scouts to monitor large hectarages more accurately and efficiently than before.

In the final trial of a program to predict late blight of potato, weather stations were maintained in four fields of Russet Burbank potatoes from the green row stage until 21 September. The trial indicated that sprays were not required in any of the trial fields until early September. In two unsprayed control fields, late blight occurred approximately when predicted by the program. A method was developed for trapping late blight spores to determine increases in field inoculum levels and thus corroborate predictions based on weather data. After 3 yr of trials, we are now confident that the prediction program is accurate and ready for use commercially. Our data suggest that in 2 yr out of 3 yr, forecasting late blight can reduce the number of sprays required to protect the crop.

Cabbage maggot. Several new organophosphate insecticides have been shown to be effective against the cabbage maggot, *Delia radicum* (Linnaeus). A Minor Use Registration has been obtained for Lorsban 4E on cabbage, cauliflower, and broccoli and this chemical will probably be widely used in 1985.

Wireworms. Seed treatments and furrow treatments with six insecticides were compared for the control of wireworms, *Agriotes obscurus* Linnaeus, in corn in heavily and lightly infested silt loam. In the heavy infestation, furrow treatments with granules of terbufos, chlorpyrifos, and cloethecarb having an active ingredient (a.i.) of 1.5 kg/ha, or a seed treatment of diazinon–lindane combination (Agrox D-L Plus), all gave good early protection to seeds and seedlings. The furrow treatment with terbufos gave significantly greater yield of plant weight and marketable cobs than any other treatment and the greatest reduction in the wireworm population. Chlorpyrifos, isophenfos, and acephate seed treatments gave some early protection but no residual protection, so yields were very low. In the light infestation, treatments made no significant difference in the number of plants, but the number of marketable cobs was significantly greater in the cloethecarb furrow and the diazinon–lindane seed treatment than in the untreated check. Terbufos gave the greatest reductions in the wireworm population, but all treatments except isophenfos gave significant reduction over the check.

Weeds. Larvae of the weevil *Campylirhynchus pericarpius* (Linnaeus) (previously reported as *Rhinonchus pericarpius* (Linnaeus) seriously

damage the roots and crowns of broad-leaved dock, *Rumex obtusifolius* L. Field cages were used to test the effect of the weevil on this weed, with and without competition from grass. Grass and dock were harvested three times to simulate cutting for hay. Fifty larvae either killed the dock or reduced its growth. Competition from grass did not affect the efficacy of the weevil.

Residue chemistry

The European asparagus aphid. A 3-yr study on the management of the European asparagus aphid, *Brachycolus asparagi* (Mordvilko), was completed in 1984. Efficacy and degradation of several insecticides including the partly systemic methamidophos, dimethoate, and pirimicarb, and the fully systemic disulfoton, demeton, and oxydemeton-methyl were determined. All these chemicals degraded readily under field conditions. After application, disulfoton, demeton, and oxydemeton-methyl oxidized rapidly in the foliage to the sulfoxides and sulfones of the parent compound and its oxygen analogue; dimethoate partly converted to dimethoxon and pirimicarb to its methylamino- and formyl methylamino-analogues. The total residues including toxic metabolites were all degraded in 30 to 60 days. No residue at the limit of detection of 0.002 ppm was present in the marketable spears harvested in the following spring and early summer. Our studies clearly indicated that the marketable asparagus spears are free from any detectable residue after these insecticides have been used for aphid control on asparagus foliage. Based on our efficacy and degradation studies, both dimethoate and pirimicarb are now registered under the Minor Use Program.

Root maggots. Two insecticides, terbufos and chlorpyrifos, are being evaluated for control of root maggots in cole crops. Analytical methods for determining terbufos, chlorpyrifos, and their toxic metabolites and breakdown products were developed. The method for terbufos is capable of identifying and quantifying individually the parent compound and all its toxic oxidative metabolites. The method for chlorpyrifos is applicable to the determination of the parent compound and its two toxic breakdown products, 3,5,6-trichloro-2-pyridinol and 2,3,5-trichloro-6-methoxypyridine in soil and cole crops.

Terbufos having an a.i. of 1.9 g/10 m row was applied as a band treatment against root maggots in cole crops. After application there were about 30 ppm residues in the soil. Terbufos oxidized to its sulfoxide and sulfone in soil. By harvest there were only about 0.7 ppm terbufos present in the soil. During the early growing season terbufos translocated from soil into the plants. The highest concentration detected in the plants was about 8 ppm but only traces (<0.01 ppm) of terbufos were found in the marketable crops.

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